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BASELINE GEOLOGY AND HYDROLOGY REPORT FOR ALTERNATIVE DAM SITES ON THE LOWER KOOTENAI RIVER - KOOTENAI RIVER HYDROELECTRIC PROJECT

by

Charles Dalby

Geologist

Department of Natural Resources

and Conservation

February, 1981

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Introduction

The Montana Department of Natural Resources & Conservation (DNRC) is reviewing the application of Northern Lights, Inc., for construction of a hydroelectric dam at Kootenai Falls. The project application lacked sufficient baseline environmental and social data to allow evaluation of the alternative hydropower sites on the Kootenai River. Consequently, DNRC agreed to provide additional baseline data for the company's selected alternative sites. These sites, located on the Kootenai River near the mouths of Katka, Rocky, Ruby and O'Brien creeks are shown in Figure 1, along with the preferred site for the Kootenai River hydroelectric project.

Scope of Report

This report provides additional baseline geologic and hydrologic data for the four alternative sites. This information is derived mainly from (1) a review of existing geologic and hydrologic literature, (2) data collected by the U.S. Geological Survey (USGS) and U.S. Army Corps of Engineers (USCE), (3) limited reconnaissance-level field investigations at each site, and (4) a survey of potential reservoir boundary material conducted by GeoServices West.

The study area, as defined for this report, includes the 20-mile reach of the Kootenai River extending from a point 3.2 miles west of the Montana/Idaho border to a point about four miles east of Troy (see Figure 2). For the purposes of geologic description, special attention is given to the area within a one-mile radius of the dam site and to the areas which would be contained within the reservoir pool boundary of each potential dam site. A generalized analysis of watershed and streamflow characteristics is given for the purposes of hydrologic description.

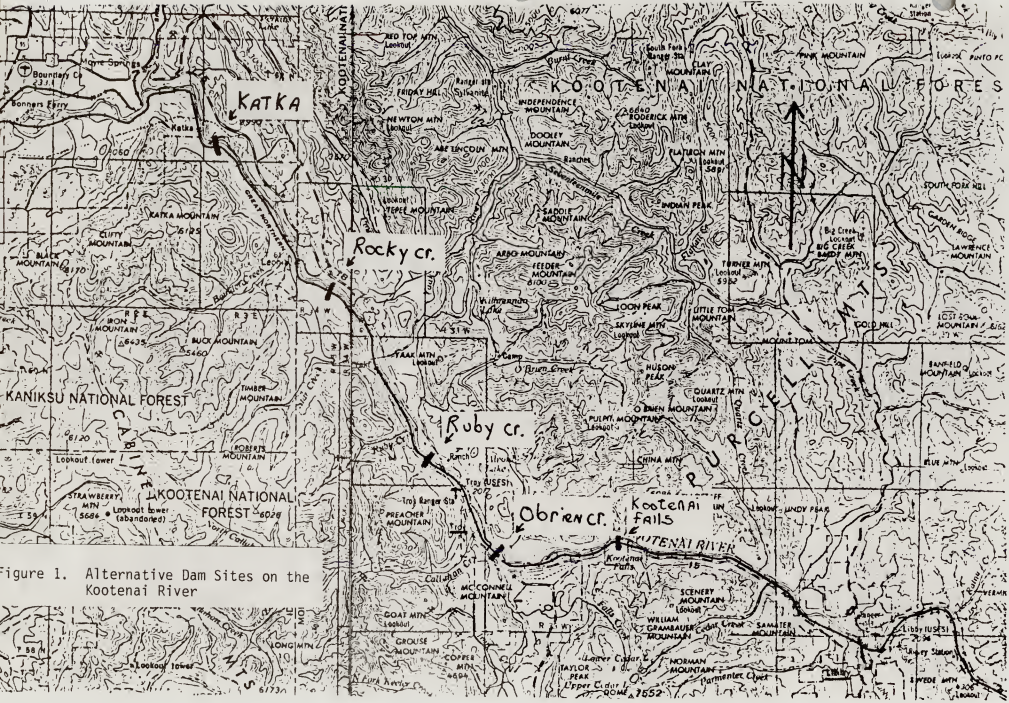

Figure 1. Alternative Dam Sites on the Kootenai River

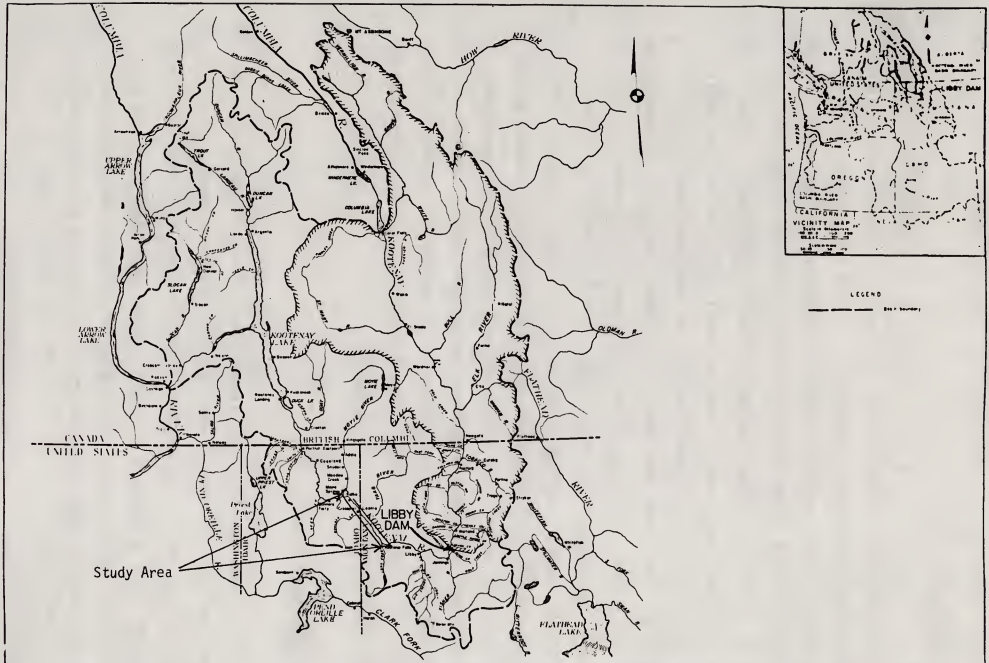

Figure 2. Kootenai River Drainage Basin (Source: USCE, 1975a)

Acknowledgments

This report was prepared under contract to the applicant, Northern Lights Inc., an Idaho Rural Electric Cooperative. James Sewell and Associates of Newport, Washington, and HARZA Engineering of Chicago, provided potential dam site locations and reconnaissance-level project design and engineering data. The U.S. Army Corps of Engineers, Seattle District office, provided source materials regarding regional geology, seismicity, hydrology and water quality. Geologists Richard Galster and Bob Searing were especially helpful. The U.S. Geological Survey, Water Resources Division (Helena, Kalispell, and Boise Branch Offices) performed statistical analyses of streamflow characteristics for selected lower Kootenai River Basin stations and provided detailed gaging station information. Jay Diamond (Helena), Ernie Hubbert (Boise) and Ed Blank (Kalispell) were very helpful. Lou Kuennen, Soils Scientist, Kootenai National Forest, Libby, provided a review of local soils data and useful suggestions. Daniel O'Haire of GeoServices West was subcontracted to aid in preparation of a reconnaissance level investigation of surficial geology and groundwater of the study area. Mike Rubich, DNRC, assisted in collection of data. Ray Breuninger DNRC, provided useful comments and suggestions.

Organization of Report

This report is organized as follows: First, a general description of the study area's general watershed characteristics (basin description, climate, river description, water quality, streamflow and geologic characteristics) is provided. Next, a general description of the proposed alternatives is given. In the final section, there is a more detailed description of site-specific geologic characteristics. Compiled information pertinent to the description and

evaluation of possible environmental impacts at the sites but not pertinent to discussion in the text is included in the Appendix.

II Watershed Characteristics

Basin Description

The Kootenai River originates in the Canadian Rocky Mountains of British Columbia and flows southward into Montana, making a broad horseshoe-bend before reentering Canada and joining the Columbia River (see Figure 3). The total drainage area is 19,300 sq. miles. The basin is about 238 miles long and 153 miles wide. Elevation ranges from a maximum of 11,870 ft. in the headwaters to 1370 ft. at the Kootenai's confluence with the Columbia. Generally, about 50% of the basin exceeds 6,000 ft (USCE 1975). A summary of basin area and river elevation characteristics is included in Table 1 and Figure 4.

Climate

The elevation and orographic affect of local mountain masses strongly influence the climate of the Kootenai River Basin. With the westernmost extension located 325 miles from the Pacific coast, the Kootenai Basin's climate is affected by both Pacific maritime and continental influences. Maritime influences are strongest during the winter and result in snowfall when the relatively warm moisture-bearing air masses pass over the basin. Continental influences tend to be strongest in summer when the northern edge of continental low pressure areas cause occasional cloudbursts and heavy convective-type showers. Generally, most precipitation (approximately 65%) is received as snowfall during winter months (USCE 1975; USFS and DSL 1977).

Figure 3 ERTS photomosaic of the Kootenai River drainage basin; images acquired on 7 and 8 Feb 73; approximate location of the United States-Canada border, Libby Dam (1), Lake Koocanusa (2), Kootenai River (3), and Kootenay Lake (4). (Source: USGF 1975a)

Table 1.
SUMMARY OF KOOTENAI RIVER BASIN DRAINAGE AREAS

Location	Area (between locations)	Total Area (above location)
U.S./Can. Border	6740 sq. mi.	6740 sq. mi.
Libby Dam	2245 sq. mi.	8985 sq. mi.
Re-Reg Dam	975 sq. mi.	9960 sq. mi.
Libby Gaging Sta. (USGS-12303000)	280 sq. mi.	10240 sq. mi.
Kootenai Falls Site	241 sq. mi.	10481 sq. mi.
Rocky Cr. Site	1249 sq. mi.	11730 sq. mi.
Leonia Gaging Sta. (USGS-12305000)	∿10 sq. mi.	11740 sq. mi.
Katka Site	120 sq. mi.	11860 sq. mi.
Columbia R. Confluence		19300 sq. mi.

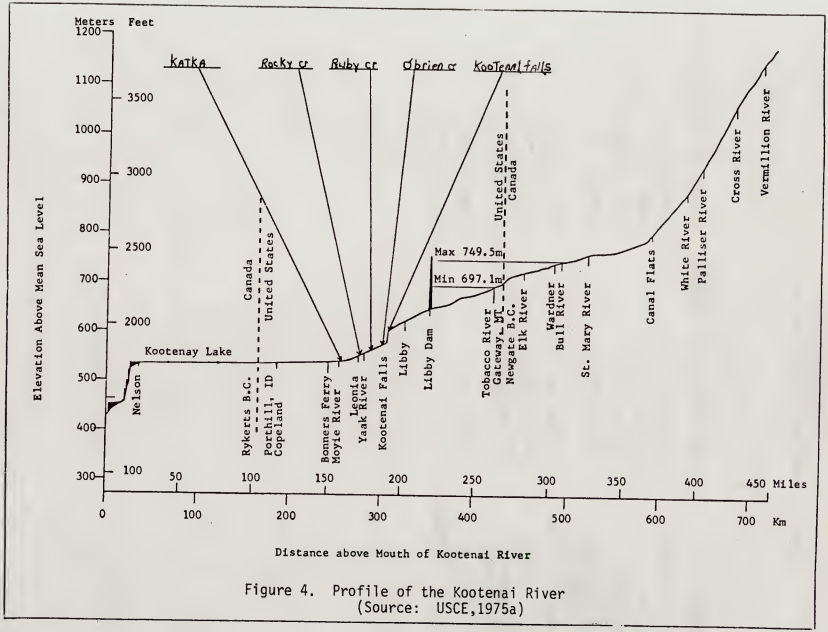

Figure 4. Profile of the Kootenai River
(Source: USCE,1975a)

Temperature and precipitation vary considerably within the study area. Mean annual precipitation for the basin is 30 inches, with extremes of 14 inches and 120 inches for the lowest and highest elevations respectively. Libby has a mean annual precipitation of 19.2 inches. Mean annual temperature for the basin is about 41 degrees F. with wide variation among reporting stations. Temperature and precipitation data for Libby and Troy are summarized in Tables 2 and 3.

River Description

The Kootenai River is about 485 miles long with 165 miles within the United States. River mileages to selected features and the alternative sites in the U.S. are shown in Figure 4.

The river system is coarse-bedded and dominantly alluvial, occupying a broad-to-narrow glacial valley with a floodplain of varying width. Within the study area the Kootenai River may be divided into three distinct fluvial geomorphic provinces: (1) a short channel reach, with a steep gradient (46 ft/mi) and a bedrock-controlled channel, extending downstream approximately two miles from China Rapids through the Kootenai Falls gorge to the gorge outlet, (2) a long, dominantly alluvial channel reach with a moderate gradient of 4.4 ft/mi. extending from the outlet of the Kootenai Falls gorge approximately 10 miles to the mouth of the Yaak River and (3) a dominantly bedrock controlled 12-mile channel reach with a moderate gradient of 4.3 ft/mi, extending from the mouth of the Yaak River to the Katka alternative dam site.

Major tributaries to the Kootenai between Libby Dam and the Katka site include, in downstream order: Fisher River, Libby Creek, Granite Creek, Lake Creek, Callahan Creek, Yaak River, and Boulder Creek. Numerous smaller tributaries have built deltas composed of rocks 50 to 200 mm in diameter. The

CLIMATOLOGICAL ELEMENTS	YEARS OF RECORD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
TEMPERATURE (°F)														
MEAN MAXIMUM	62	31.2	38.9	49.4	61.8	70.7	77.5	87.5	85.8	74.4	59.6	41.4	32.7	59.4
MEAN MINIMUM	62	13.4	16.9	23.5	29.9	36.6	42.3	45.4	43.1	37.5	31.8	24.7	18.1	30.3
MEAN	62	22.3	27.9	36.4	45.9	53.7	59.9	66.5	64.4	56.0	45.7	33.0	25.4	44.9
EXTREME MAXIMUM	62	57	63	75	93	102	106	109	109	102	89	73	65	max 109
EXTREME MINIMUM	62	-46	-37	-20	-5	12	24	29	26	13	-7	-27	-38	min -46
PRECIPITATION (inches)														
MEAN	67	2.26	1.56	1.45	1.03	1.43	1.59	0.86	0.91	1.29	1.76	2.73	2.32	19.19
MEAN AS PERCENT	67	11.8	8.1	7.6	5.4	7.4	8.3	4.5	4.7	6.7	9.2	14.2	12.1	100.0
MAXIMUM MONTHLY	67	6.92	3.64	4.51	2.65	4.07	4.30	5.44	2.89	4.25	5.18	9.34	8.06	----
YEAR OF MAXIMUM MONTH	67	1953	1904	1904	1907	1923	1897	1902	1954	1959	1951	1897	1933	----
MINIMUM MONTHLY	67	0.36	1.00	0.13	0.10	1.00	0.26	1.00	0.00	1.00	0.09	0.16	0.15	----
YEAR OF MINIMUM MONTH	67	1928	1934	1937	1908	1921	1949	1945 1953	1934	1943	1911	1936	1930 1935	----
MAXIMUM YEAR (1951)	67	2.17	2.69	1.28	1.72	3.64	0.62	5.44	0.61	1.51	0.63	5.91	5.81	32.03
MINIMUM YEAR (1935)	66	2.28	0.27	1.35	0.93	0.48	0.64	0.56	0.11	0.29	0.84	1.28	0.15	9.18
MAXIMUM 24 HOURS	66	2.04	0.89	1.15	1.25	1.25	1.60	3.12	1.60	1.76	1.50	2.42	1.17	---
YEAR OF MAX 24 HOURS	--	1953	1949	1903	1922	1900	1923	1902	1906	1959	1910	1897	1902	---
SNOWFALL (inches)														
MEAN SNOWFALL	52	15.3	10.5	5.5	0.9	1.0	1.0	0.0	0.0	0.1	0.6	9.1	15.2	57.3
MEAN MAX SNOW COVER	13	17.1	17.6	13.1	0.9	0.0	0.0	0.0	0.0	0.0	0.1	5.5	10.4	---

DATA FROM RECORDS FOR LIBBY, MONTANA INCLUDES DATA UP TO AND INCLUDING 1961 EXCEPT FOR MEAN SNOWFALL WHICH INCLUDES ONLY THE DATA UP TO AND INCLUDING 1952 BECAUSE OF INTERMITTENT RECORDS

Table 2. Representative Climatic Data for Libby
(Source: USCE, 1978a)

Table 3. Troy Ranger Station Climatic Data, 1967-1976*

Troy Years of Record - Temperature-15 - Precipitation-15

	Year	1	2	3	4	5	6	7	8	9	10	11	12	Average
Average Monthly Temperature														
Troy	1976	26.9	28.9	30.2	41.4	52.4	63.3	63.9	63.9	57.7	43.4	31.9	27.9	43.5
	1975	21.8	21.6	30.2	36.8	47.6	54.7	68.6	60.4	55.5	42.9	30.5	28.0	41.6
	1974	21.8	29.5	31.7	41.4	44.9	61.0	63.1	62.2	54.9	42.8	32.6	27.9	42.8
	1973	16.2	28.9	36.5	41.5	51.5	57.8	64.5	64.9	55.8	43.2	28.1	26.7	43.0
	1972	17.3	28.4	36.0	38.1	52.2	58.6	61.7	66.4	51.1	43.3	34.8	20.4	42.4
Total		104			198.2			321.2			215.6			213.3
Average		20.8			39.64			64.24			43.12			42.66

Total Precipitation

1976	27.91
1975	40.81
1974	45.99
1973	35.36
1972	36.27
Average	

Frost Free Days

	94
	88
	134
	96
	109
Average	104.2

Daily Variations

Troy - H 94 (06/76)
L -16 (01/74)

*(Source: USFS and DSL,1978)

Table 3. (Continued) Climatic Data for Troy Ranger Station 1967-1976*

Rainfall by Month-Troy - 1967-1976

nth	1976	1975	1974	1973	1972	1971	1970	1969	1968	1967
1	3.40	4.49	10.39	3.93	6.57	8.82	5.30	5.96	4.36	3.85
2	5.02	5.23	4.04	1.09	5.77	2.05	3.34	2.04	3.15	1.06
3	2.15	2.96	6.37	2.08	2.46	3.70	2.17	1.64	3.35	2.03
4	1.94	1.87	3.10	.94	2.31	2.92	2.78	2.29	2.31	.66
5	1.80	2.63	1.89	1.50	1.51	1.45	1.13	3.32	2.52	1.27
6	2.16	1.64	2.76	2.91	2.72	2.43	1.87	4.92	2.71	2.30
7	1.06	.69	1.96	.15	2.37	1.32	1.15	.49	1.84	.50
8	4.78	3.49	1.06	.70	.77	1.28	.20	.04	2.50	.07
9	.30	.64	1.25	1.84	1.79	1.72	2.58	3.92	5.68	.42
10	1.80	5.83	.27	2.47	2.16	3.08	2.04	2.38	5.50	7.97
11	1.74	3.54	7.83	10.81	2.10	3.98	2.96	2.14	5.13	2.94
12	1.76	7.80	5.07	6.94	5.74	6.37	6.16	3.33	5.12	3.85
TAL	27.91	40.81	45.99	35.36	36.27	39.12	31.68	32.47	44.16	26.92

verage Precipitation - October through March.

15.87 - 27.91 - 57	percent	1976
29.85 - 40.81 - 73	percent	1975
33.97 - 45.99 - 74	percent	1974
26.87 - 35.36 - 76	percent	1973
24.80 - 36.27 - 68	percent	1972
28.00 - 39.12 - 72	percent	1971
21.97 - 31.68 - 69	percent	1970
17.49 - 32.47 - 54	percent	1969
26.61 - 44.16 - 60	percent	1968
21.70 - 26.92 - 81	percent	1967

Average - 68.4 percent

*(Source: USFS and DSL, 1978)

building of these deltas may have been enhanced by Libby Dam flow-regulation and the consequent decreased competency of river flows. Figure 5 summarizes the major tributaries to the Kootenai River and their mean discharge into the river.

Streamflow Characteristics

Since completion of Libby Dam, a 370 ft (height above streambed), concrete-gravity structure with 420 MW (megawatts) installed capacity (see Figure 2), flows have been regulated for base load and peaking power production. River flows below the dam are decreased in summer and increased in winter, rather than following the natural flow pattern. Peak power production results in sharp fluctuations between maximum and minimum daily discharges (USCE, 1975b).

Generally, average daily releases from Libby Dam are in the 5,000 to 9,000 cfs range from April to mid-July to allow reservoir filling. Once the reservoir is filled, outflow is increased to match inflow (normally about 20,000 cfs). Natural inflows normally are passed through the reservoir until sometime in October when inflow recedes to about 8,000 cfs. Average discharges are increased to 10,000 to 20,000 cfs during winter while the pool is lowered to produce peaking power and provide storage capacity for the next spring run-off. Abnormal conditions, such as a large snowpack forecast, may result in releases of 20,000 to 40,000 cfs during winter to provide increased storage and allow discharges of 20,000 to 50,000 cfs during the spring-summer flood season.

The USCE and the Montana Department of Fish, Wildlife, and Parks (MDFWP) have cooperatively placed restrictions on flow releases from Libby Dam. The normal minimum outflow is 4,000 cfs with 2000 cfs as the absolute minimum. From May through September, the maximum allowable downstream increase in river stage (water surface elevation) is 1 ft/hr, not to exceed 4 ft/day. In the period of

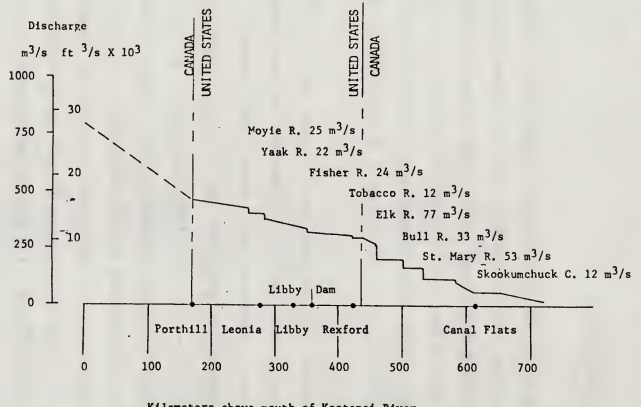

Figure 5. Mean Discharge of the Kootenai River and its Major Tributaries (Source: USCE 1975a)

October through April a maximum stage increase of 2 ft/per hour and not more than 6 ft/day is allowed (USCE,1975b).

The USCE currently is installing four additional 105 MW turbines in Libby Dam, which will increase the hydraulic capacity from 23,000 cfs to 46,000 cfs, and double both the peaking capability of the dam and the downstream water flow fluctuations. The USCE plans to build a reregulating dam 10 miles downstream from Libby Dam to maintain downstream fluctuations within the established limits mentioned earlier (USCE 1975b). If constructed, the Reregulating Dam would be a 70 ft (height above streambed) earth and rock filled structure with a concrete spillway and an installed hydroelectric capacity of about 75 MW.

Figure 6 summarizes the annual hydrograph of the Kootenai River at Libby prior to flow regulation by Libby Dam. The following generalizations are apparent for the period from 1910 to 1962: (1) at some time during the May-July period, daily maximum discharge exceeded 50,000 cfs with flood peaks approaching 100,000 cfs, (2) mean daily discharge from mid-May through mid-June was about 40,000 cfs, (3) daily minimum discharges from mid-May through mid-July were greater than 10,000 cfs, (4) for the January-April and August-December base-flow periods, the daily minimum flow was generally greater than 2,000 cfs, daily mean discharge was about 4,000 cfs, and daily maximums fluctuated about 10,000 cfs with peaks as great as 30,000 cfs.

The general effect of flow regulation by Libby Dam is indicated in Figure 7 which shows mean monthly discharges for representative years before (1970) and after (1977) regulation. Flow duration, cumulative high and low flows, and peak flows were analyzed to obtain a more complete comparison of streamflow characteristics prior to and after the beginning of flow regulation at Libby Dam. Statistical analyses were requested from the USGS gaging stations located

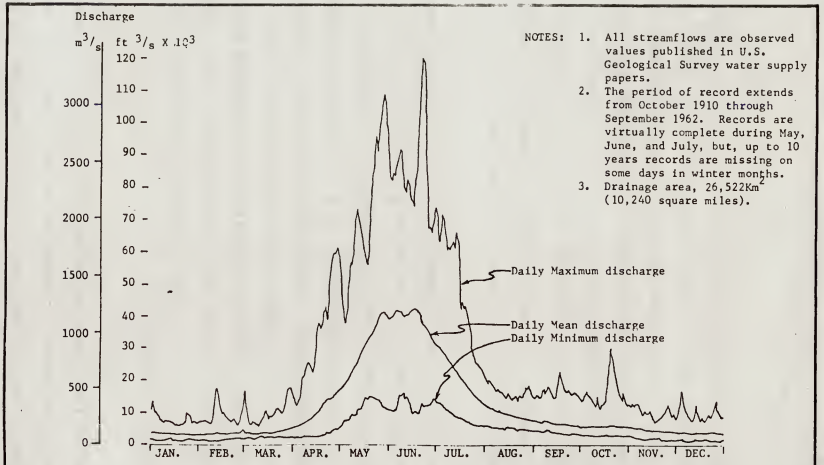

Figure 6. Summary Hydrograph for the Kootenai River at Libby, Mont. (Source: USCE 1975a)

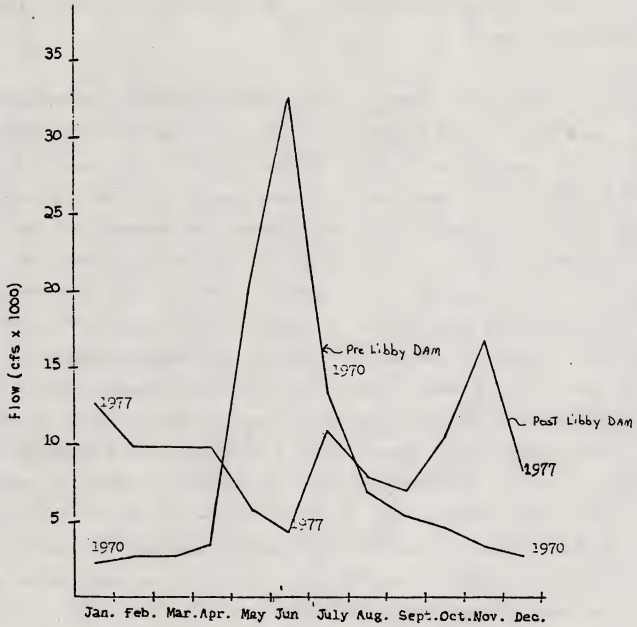

Figure 7. Monthly Averages of Mean Daily Discharge Downstream from the Libby Dam Site Prior to Impoundment (1970) and Following Impoundment (1977). (Source: Graham 1979)

near Libby (12-303000) and at Leonia, Idaho (12-305000). The stations are located approximately 18 and 52 miles downstream from Libby Dam. These data and the statistical analyses of Fisher River and Yaak River flow characteristics are included in Appendix A.

Analysis of annual peak-flow characteristics for the Libby station indicates that for the period of record 1911-1971: the 1.5 yr. recurrence interval (RI) event* was about 58,000 cfs and the 100-year RI event was approximately 105,000 cfs (based on Log-Pearson Type III frequency distribution). For the period 1972-1979** the Libby station had the following flood frequency characteristics (1) the 1.5 yr. RI event was about 27,000 cfs, the 50 yr. RI event was about 46,000 cfs and the 100 yr. RI event was about 48,000 cfs. Thus, under the present flow regulation of Libby Dam, the 100-yr. flood downstream from Libby Dam is slightly less than the 1.5 yr. flood of the prior unregulated flow period. Figure 8 shows an estimate of peak discharge frequency prepared for Libby Dam (USCE 1975b). The lower right curve (for four power units in Libby Dam) indicates a 100 yr. flood estimate of 50,000 cfs for Libby Dam, which agrees with the Log-Pearson analysis for the 1972-1979 short period of record. Description of cumulative high and low flow and flow duration characteristics of the Kootenai River stations before and after the beginning of flow regulation at Libby Dam is included in Appendix A. A detailed comparison is not included in this report because of its extreme length.

A summary of extreme and average flow characteristics for the USGS stream-gaging stations located on the Kootenai below Libby Dam, the Fisher River near Libby, the Kootenai River near Libby, the Kootenai River at Leonia, Idaho and the Yaak River near its confluence with the Kootenai is provided in Table 4.

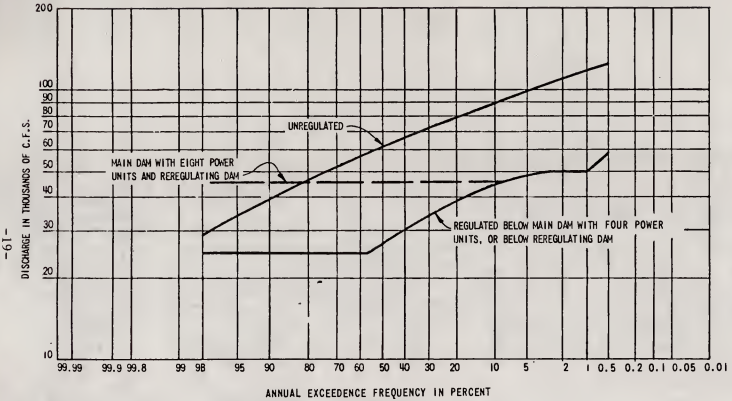

Figure 8. Peak Discharge Frequency for Libby Dam *

NOTES:

1. REGULATED CURVES ARE BASED ON ROUTINGS SIMULATING OPERATION WITH 1929 THROUGH 1958 INFLOW AND ON OPERATIONAL CONSTRAINTS WHICH WILL APPLY UNDER ACTUAL OPERATING CONDITIONS.
2. UNREGULATED CURVE IS BASED ON HYDROGRAPHS RECONSTITUTED BY N.P.D. FOR 1929 THROUGH 1961 (33 YRS) AND U.S.G.S. WARLAND DATA FOR 1962 THROUGH 1971 (10 YRS).
3. ANALYTICAL PROCEDURES USED AS DEFINED BY BEARD IN "STATISTICAL METHODS IN HYDROLOGY".
4. RECORD EXTENDED TO AN EQUIVALENT 60.8 YEARS BY CORRELATION WITH KOOTENAI RIVER AT LIBBY, MONTANA.
5. DRAINAGE AREA ABOVE LIBBY DAM IS 8985 SQUARE MILES.

*(Source: USCE 1975b)

Table 4.
SUMMARY OF AVERAGE AND EXTREME FLOW CHARACTERISTICS FOR SELECT LOWER KOOTENAI BASIN GAGING STATIONS

Station	Period of Record	Drainage Area	Av. Discharge	Minimum Discharge	Maximum Discharge
Fisher River near Libby (12302055)	Sept. 1967-present	838 mi^2	522 ft^3/s (378,200 ac-ft/yr)	29 ft^3/s (Jan. 2, 1977)	6,560 ft^3/s May 22, 1948)
Kootenai River below Libby Dam(12301933)	Oct. 1971-present	8,985 mi^2	11,830 ft^3/s (8,571,000 ac-ft/yr)	1900 ft^3/s (Jan. 29, 1972)	47,200 ft^3/s (Aug. 5, 1974)
Kootenai River at Libby (12303000)	Oct. 10, 1910-present	10,240 mi^2	12,180 ft^3/s (8,824,600 ac-ft/yr)	895 ft^3/s (Jan. 11, 1930)	121,000 ft^3/s (June 21, 1916)
Yaak River near Troy (12304500)	Oct.1^, 1910-present	766 mi^2	916 ft^3/s (663,000 ac-ft/yr)	50 ft^3/s (Dec. 9, 1972)	13,400 ft^3/s (May, 1954)
Kootenai River at Leonia, ID (12305000)	March, 1928-present	11,740 mi^2	14,020 ft^3/s (10,160,000 ac-ft/yr)	966 ft^3/s (Dec. 9, 1936)	123,000 ft^3/s (May 28, 1948)

(SOURCE: U.S. Geological Survey (Dec. 1979), Water Resources Data for Montana-Water Year 1978)

Water availability for power production in the Kootenai River may be affected by future flow diversions from the Kootenai River in Canada. The "Columbia River Basin Cooperative Development Treaty of 1961" (Witmer 1968) gives Canada the right to the following diversions:

A) Up to 1984 the Canadians may divert as much as 1.5 million acre-feet of water per year from the Kootenai River in the vicinity of Canal Flats, British Columbia, provided that the diversion does not reduce the flow of the river immediately downstream from the point of diversion below the lesser of 200 cfs or the natural flow.

B) From the year 2024 to 2064 Canada may divert to the headwaters of the Columbia River any water which, in its natural channels, would flow in the Kootenai River across the US/Canada boundary, provided that the diversion does not reduce the flow of the Kootenai in the vicinity of Newgate, British Columbia below the lesser of 2500 cfs or the natural river flow.

C) From the year 2044 to 2064, Canada may divert only the lesser of 1,000 cfs or the natural flow.

The first diversion (A) is the most significant and would comprise about 20% of the average annual runoff of the Kootenai River at Libby. The applicant has determined that this would correspond approximately to a 20% reduction in available power from the proposed Kootenai River hydroelectric project (NLI, 1978). With power production directly proportional to average annual discharge, it can be roughly estimated that the first flow diversion would reduce average annual energy at potential dam sites by approximately 15 to 20 percent in the Libby Dam to Katka site portion of the river.

The two later diversions (B and C) are not expected to significantly affect downstream power generation because of their small size and late dates (NLI 1978).

Water Quality

The Kootenai River is a calcium-carbonate, hard-water stream with a generally higher nutrient content than usually found in the intermountain region. Water quality of the Kootenai downstream from Libby Dam is influenced by water releases from Lake Koocanusa. Graham (1979) observed changes in temperature, dissolved gas levels, total phosphorous, suspended solids, and specific conductance attributable to Libby Dam operation.

Several detailed studies of Kootenai River water quality merit brief mention here. The U.S. Army Corps of Engineers (USCE), in cooperation with the U.S. Geological Survey (USGS) and Montana Department of Fish, Wildlife, and Parks (MDFWP), maintained a network of water quality stations in the lower Kootenai River Basin from October 1967 to March 1972. Water discharge, temperature, suspended sediment, turbidity, water chemistry and bottom fauna were measured for the Fisher River, the Kootenai River near Libby Dam, the Kootenai River near Libby, and the Kootenai River at Leonia and several other locations (USCE 1975a).

Graham (1979) reviewed existing water quality data and analyzed the aquatic environment of the Kootenai River in the vicinity of the proposed Kootenai River hydroelectric project. He produced data on water discharge, temperature, gas supersaturation, total phosphorous, dissolved orthophosphate, pH, specific conductance, aquatic habitat, and fish populations. He also compared water quality parameters downstream from Libby Dam for water years 1970 and 1977.

Graham observed a decrease in total phosphorous and dissolved orthophosphate following startup of Libby Dam generation. He attributed this to the clean-up of Canadian fertilizer operations and to nutrient trapping in Lake Koocanusa. The pH ranged from 7.0 to 8.5 in both years, and specific conductance was slightly lower and more uniform in 1977 (range of 200 to 370 micromhos for 1970; range of 200 to 290 micromhos for 1977). Graham also noted that the percent of total gas supersaturation at the Leonia gaging station appears to be independent of the operation mode (turbine, sluice, spillway combination) of Libby Dam, as indicated in Figure 9. Generally, supersaturation downstream of Libby Dam is higher during sluice and spillway discharges than during turbine discharges. The lack of a similar trend in Figure 9 indicates that river processes ameliorate supersaturation by the time flows reach Leonia.

The Water Quality Bureau of the Montana Department of Health and Environmental Sciences (MDHES) describes the Kootenai River Basin water quality as follows.

> Waters of the Kootenai drainage have soft to medium hard, calcium/magnesium/bicarbonate waters. Low alkalinities help explain why these waters are relatively unfertile and their low buffering capacity makes them among the most sensitive in the state to heavy metals pollution. The principal water quality problems in the basin are nutrient enrichment to Lake Koocanusa from Canadian sources, and gas supersaturation in the Kootenai River below Libby Dam. Logging and mining have affected water quality in various tributaries...all waters in the drainage are classified B-D, (B-1) or better except a portion of Rainy Creek, which is classified C-D, (C-1) (MDHES 1980).

Surface water within these categories generally is suited for household use after conventional treatment, and for bathing, swimming and recreation; maintenance of salmonid fish populations and other aquatic life; and agricultural or industrial water supply (MDHES 1980).

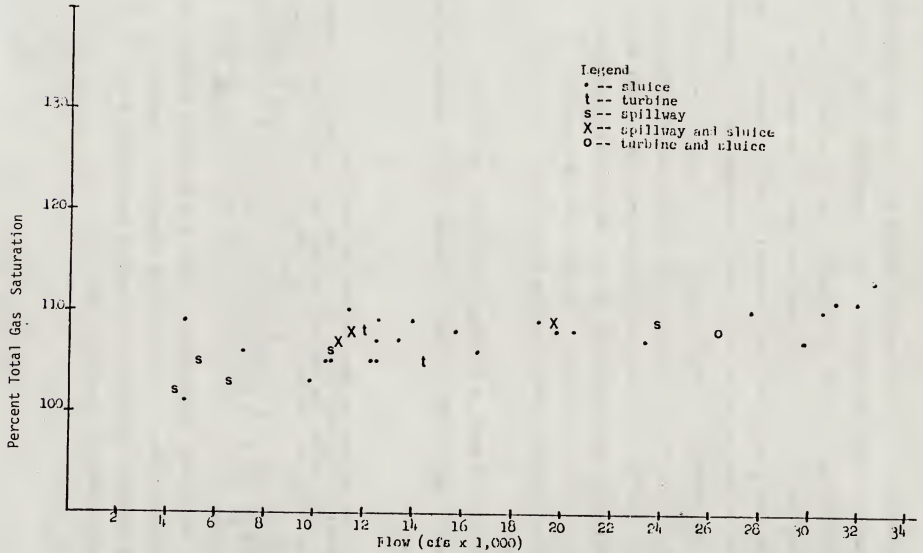

Figure 9. Percent Total Gas Saturation in the Kootenai River at Leonia (MT/ID Border) for Different Dam Operation Modes. Measured from 1972-1975. (Source: Graham 1979)

Geology

The study area is located in the western part of the northern Rocky Mountain physiographic province (Fenneman 1931). Surrounding the study area is a series of structurally-controlled, linear, northwest-trending mountain ranges and narrow intermontane valleys (see Figure 3). Two of the larger valleys are broad enough to be considered trenches. The Purcell Trench lies west of the study area and the Rocky Mountain Trench lies to the east. Within the study area, the relatively narrow, northwest-trending Kootenai valley connects the two trenches.

The area is underlain by a thick conformable sequence of Precambrian metasediments of the Belt Supergroup, consisting primarily of argillite, siltite, quartzite, sandstone and carbonates (limestone and dolomite) of varying purity (Johns 1970). These Precambrian rocks have been subdivided by Ross (1959) into four major groups, which in ascending order are: (1) the pre-Ravalli Group, or Prichard Formation, (2) the Ravalli Group, (3) the Piegan Group and, (4) the Missoula Group. Rocks of the Prichard Formation and (Piegan Group) Wallace formation predominate within the study area (Miller 1973, Johns 1970). The former is almost entirely argillite, siltite and quartzite; the latter is dominantly a carbonate. Minor amounts of diorite, metadiorite and gabbro intrude the rock sequence locally. All of the rocks have been subjected to low-grade metamorphism.

The area has a complex tectonic history. Structurally it is characterized by broad to tightly-compressed and shallow to deeply-folded beds. North to northwest-striking normal faults and moderate-to-high angle overthrust and reverse faults displace the folds (Johns 1970). Jointing is pronounced and well-developed in Beltian rocks within the study area. Proximity to major

faults and folds exerts an important control on joint spacing and attitude, which in turn influence the physical integrity and suitability of bedrock as foundation materials at each potential dam site.

With structural influences providing the basic physiographic control, extensive Pleistocene continental and alpine glaciations have largely modified the landscape to its present form. Accordingly, surficial deposits within the study are primarily glacial till and outwash, and river alluvium. There are minor deposits of glacial lake silts.

Soils

Most of soils in the study area are fluvially or glacially derived. Extensive continental and alpine glaciation during the Pleistocene left a complex mixture of drift in the Kootenai River valley. Glacial deposits consist mainly of poorly sorted till, partly reworked glacio-fluvial materials with interbedded lenses of gravel, clay and silt, glacial lake sediments, and ice-contact deposits. These deposits vary in thickness from tens to hundreds of feet, lie uncomformably over Precambrian metasediments, and are generally widespread in the study area. Notable exceptions are the inner bedrock gorges of the Kootenai River where appreciable Holocene downcutting has removed most Pleistocene glacial deposits.

In the process of downcutting, the Kootenai River produced a series of stepped river terraces which are pronounced in the vicinity of the Yaak River mouth. These terraces commonly have gravelly silt loam soils formed in alluvium or till, and are capped by loess that contains volcanic ash. Surface soil depth ranges from 0 to 10 in. with subsoils from 30 to 60 in. Unified Soils Classification varies from ML to GP-GM and the soils have a low shrink-swell

potential. Infiltration capacities vary from about 0.6 in. to 20 in/hr (USDA 1980; Anderson and Hunter 1980).

The active valley flat (floodplain) in the vicinity of the Kootenai River tributaries and the main channel consists of a thin layer of alluvium overlying till or bedrock. Recent alluvium is mainly well-drained sand, gravelly sand, sandy gravel, and gravel with cobbles and boulders (all SM to GP-GM, GW). Infiltration capacities in the area generally are high (2 to 20 in/hr) and shrink-swell potential is low (Anderson and Hunter 1980).

Soils derived from glacial lake sediments are of relatively minor extent within the study area. Extensive lake silts were deposited within Pleistocene Glacial Lake Kootenai, which was formed when ice or morainal materials originating in the Purcell Trench periodically blocked the Kootenai drainage in the vicinity of Bonner's Ferry (Alden 1953). Thick sequences of silt are exposed in the vicinity of Libby, Lake Creek and the Bull Lake valley, and in a high terrace above the Yaak River mouth. However, within the study area, particularly in bedrock-confined channel reaches, there are few lake silt deposits.

More detailed site-specific soils data for the study area are included in two recent reports by the Soil Conservation Service (Chugg and Fasberg 1980, Anderson and Hunter 1980).

Regional Tectonics and Seismicity

Introduction

The four alternative hydropower sites (Katka, Rocky, Ruby, O'Brien creeks) are located within the Purcell Anticlinorium (Figure 10) (Harrison 1972, USCE 1978). This geologic and tectonic subprovince lies northwest of the end of a continental zone of contemporary seismicity known as the Intermountain Seismic Belt. The proximity of dam sites (especially Katka) to major regional structures such as the Leonia Fault requires that special attention be given to local and regional seismicity in dam siting and design.

This reconnaissance level report does not provide detailed site- specific analysis of fault activity within the study area. However, the USCE has performed extensive analyses of regional tectonics and seismicity with emphasis on an area within a 100-mile radius of the proposed Libby Reregulation Dam (USCE 1975b, 1978). The four alternatives considered in this report lie roughly 30 miles due west of the Reregulation Dam site and within three miles of the Leonia fault. Figure 11 shows the location of the Leonia Fault and other regional faults within the study area. The following discussion is based largely on geologic and seismologic work by USCE (1975b, 1978) for the Libby Reregulation Dam project.

Generally, the Purcell Anticlinorium has wide-spaced, high-angle faults (O'Brien Creek Fault, Savage Lake Fault) and broad, open-folds of north-northwest orientation (Sylvanite Anticline, Kootenai Anticline). This northern subprovince is separated from a more active southern Rocky Mountain province by the Lewis & Clark line, a zone of major left-lateral faulting which forms part of the Montana lineament (Figure 10). Structural trends and geology truncate

along this line and severe seismic disturbances have only occurred south of the line within historic times. Recent studies by the USCE (1978) indicate that the area of the Purcell Anticlinorium exhibits only scattered historic seismicity and is not a region of historic large magnitude (greater than 5.5 Richter magnitude) earthquakes.

Detailed studies of exploratory trenches in glacio-fluvial sediments overlying major faults near the Libby Reregulation Dam site revealed that the faults (Pipe Creek Fault, Blue Mountain Fault, Rainy Creek Fault) have been inactive for at least the Holocene and probably for more than 45,000 to 85,000 years (Slemmons 1977). Slemmons also indicated that 5.5 is the maximum earthquake magnitude expected in the region.

Detailed fault studies revealed no capable faults near the Reregulation Dam site, so seismotectonic zoning and seismic source analysis were used to determine a design earthquake for the Reregulating Dam. Figure 11 shows the regional historic distribution of earthquakes. There are distinct clusters of activity in the Flathead Lake, Helena, Yellowstone, and Idaho Batholith areas. Figure 12 shows the distribution of earthquakes in relation to the seismotectonic zones (USCE 1978).

With source areas identified, USCE prepared Table 5, showing the distance from the Reregulation Dam site to the nearest boundaries of potential seismic source zones, the maximum intensity and magnitude of earthquake expected for the seismic risk zone, and the attenuated intensities for the Reregulation site.

On the basis of these and other analyses, the USCE concluded that the most severe seismic hazard at the Reregulation site would be generated by an earthquake in the Purcell Anticlinorium. Motions attenuated to the Reregulation

Figure 10. Regional Seismotectonic Zones for Libby Reregualtion Project (Source: USCE 1978a)

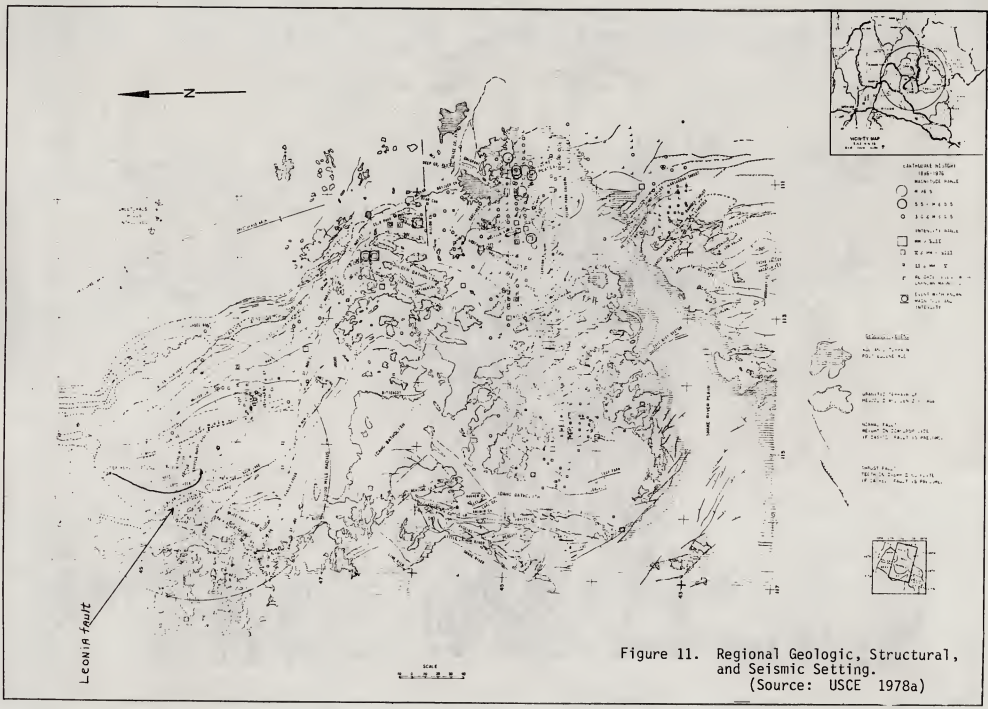

Figure 11. Regional Geologic, Structural, and Seismic Setting.
(Source: USCE 1978a)

Figure 12. Strong Seismic Sources from the Historic Earthquake Record.
(Source: USCE 1978a)

Table 5. INTERPRETED PEAK GROUND MOTIONS * AT LIBBY REREGULATING DAM SITE

ELEMENTS IN/OR SEISMIC RISK ZONE	MAX. HISTORIC INTENSITY MM	INTENSITY AT SITE (MM)1/	MAX. MAG. M 2/	DISTANCE MILES	FOCAL DEPTH KM	FIELD CHARACTER	FAULT TYPE	Libby Reregulating Dam Site 3/ ACCEL g	VEL. CM/SEC	DISPL CM	BEDROCK DURATION SECONDS
Purcell Anticlinorium	VII	VII	5.5	10-35	5	FAR	NORMAL	0.20	24	12	7-10
Lewis & Clark Line	VIII	VI	6.5	36	7	FAR	NORMAL STRIKE SLIP	0.10	14	9	7-10
Flathead Lake	VIII	V	6.75	60	5	FAR	NORMAL STRIKE SLIP	0.07	8	-	-
Mission Block	VII	V	5.3	95	>10	FAR		0.07	8	-	-
Rocky Mountain Trench	VII	V	5.3	40	5	FAR	NORMAL STRIKE SLIP	0.07	8	-	-
Dillon Block	X	V	7.6	250	16	FAR	NORMAL	0.07	8	-	-
Batholith Terrain	VIII	IV	7.0	160	16	FAR	STRIKE SLIP	0.03	4	-	-
Undeformed Plains	VI	III	5.5	225	16	FAR	NORMAL	-	-	-	-
Kootenay Mobile Belt	V	III	4.8	100	16	FAR	NORMAL	-	-	-	-

1/Attenuation Curve Figure C-7.
2/Max. Mag. taken by adding 1/2 unit to historic record or using strain rate and magnitude-fault length.
3/OBE Earthquake mag. used 1/2 value of max. peak motions.

*Source: USCE 1978a

site would have peak values of 0.2 g acceleration, 24 cm/sec velocity, 12 cm displacement, and would result from a 5.5 Richter magnitude earthquake centered 10 miles away, or a 6.5 magnitude earthquake located more than 25 miles away.

The study area is located within Coffman and Von Hake's (1973) seismic risk zone 2. Algermissen and Perkins (1976) preliminarily identified the area as having a 10% probability of acceleration exceeding .04g in a 50-year interval (see Figure 13). The preliminary map shown in Figure 13 currently is nearing completion. F.A. McKeown, a USGS goephysicist, reports that Algermissen and Perkins now estimate that the general area of the Kootenai River hydroelectric project may have a 10% probability of acceleration exceeding 0.1g in a 50-year interval (McKeown 1980). This is an increase over the preliminary figure of 0.04g.

Major Faults

Although these data are applicable to the alternative sites in a regional sense, site-specific studies of major faults within the study area would be required to establish the probability of higher local accelerations from a local earthquake. The Leonia and O'Brien Creek - Savage Lake Faults are major faults which generally parallel the Kootenai River and pass within three miles of the dam sites (Figure 11) (Johns 1970).

The Leonia fault is a regional high-angle overthrust fault 70 to 100 miles long (Kirkham 1930, Johns 1970). From Brush Creek, three miles west of Troy, the Leonia fault strikes N25 degrees W to 35 degrees W and dips near vertically to the west. In the Star Creek-Ruby Creek area, apparent vertical displacement in Belt Rock is about 32,000 ft. (Johns 1970). The Leonia fault trace is coincident with the bed of the Kootenai River for the westernmost portion of the

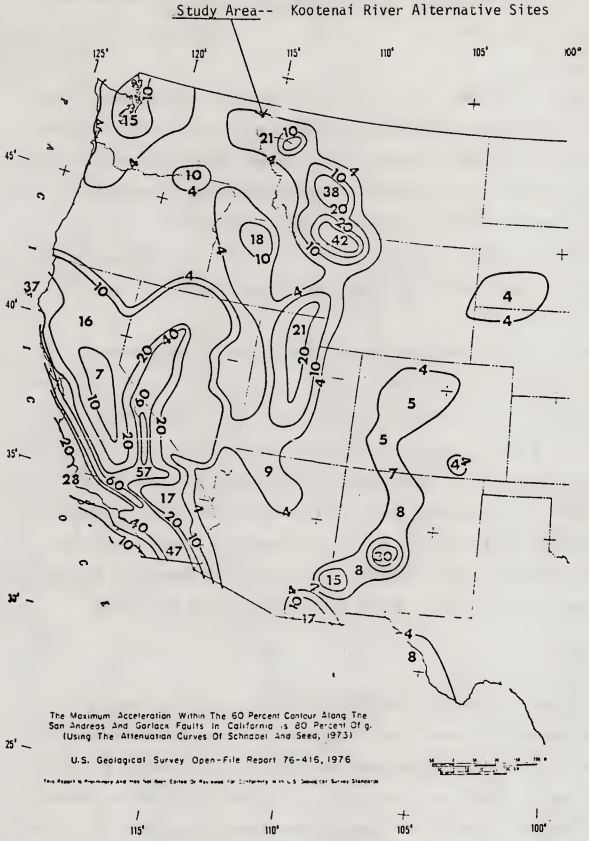

Figure 13. Preliminary Map of Horizontal Acceleration (expressed as percent of gravity) in Rock with 90 Percent Probability of Not Being Exceeded in 50 Years.

study area and leaves the bed of the river about 1,500 feet upstream of the Katka Dam site (Erdman 1947).

The O'Brien Creek-Savage Lake fault is a normal fault with a steep west dip and downthrow to the west. The O'Brien branch is a major fault about 30 miles long, which crosses the Kootenai River two miles east of the O'Brien Creek site. The Savage Lake fault is a north-northwest trending high-angle fault which connects with the O'Brien Creek Fault about eight miles north of Troy, crosses the Kootenai River three miles east of the O'Brien Creek site and connects with the northward extension of the Bull Lake fault (Gibson 1948, Johns 1970).

Both faults probably have long complex histories which may date from Precambrian time (Johns 1970). Pardee (1950), in a systematic study of active faults in Idaho and western Montana, suggested that most of the trenches in the region (including the southern end of the Rocky Mountain trench, Bull Lake-Lake Creek Valley trench, and the Libby trench) were formed in Pliocene to mid-Quaternary time (7 million years to 1.5 million years ago). Pardee (1950) and Gibson (1948) mentioned a possible 60-foot Holocene scarp along the Bull Lake fault in the Lake Creek valley near Crowell Creek. Gibson apparently was unable to resolve whether the scarp was due to differential erosion or surface faulting.

Pardee (1950) also interprets Kootenai Falls as a knickpoint propagated upstream as the result of recent uplift along the O'Brien-Savage Lake fault. This suggestion is based on the apparent lack of association between glacial features of the region and the origin of the falls, the likelihood of isostatic adjustment along the formerly ice-depressed fault block, and the ability of the Kootenai River to erode the relatively unresistant bedrock since Pleistocene time. However, additional mechanisms may be responsible for the evolution of

the Kootenai Falls. Beds at the falls consist of quartzite underlain by and interbedded with less resistant siliceous carbonate. Both dip eastward (up-river) about 15 to 40 degrees. Differential erosion across dipping strata of differing lithology and subsequent upstream migration of the knickpoint is a relatively common mechanism of waterfall origin. It is probably the dominant mechanism operating to form the Kootenai Falls. Isostatic adjustment or fault activity would tend to accelerate the process.

In summary, the alternative sites lie within a moderate-to-low seismic risk zone with regional accelerations on the order of 0.1g having a 10% probability of being exceeded in a 50-year period. Because of the proximity of the alternative sites to major faults, site-specific fault studies should be incorporated into the development of a design earthquake, if the sites are developed.

III Description of Alternatives

Introduction

Northern Lights in its FERC application proposed four alternative dam sites (Katka, Rocky, Ruby and O'Brien Creek) (Northern Lights Inc. 1978). In this application, the proposed Kootenai River Alternative Hydropower scheme would involve development of two previously recognized sites (Katka and Rocky Creek or Tunnel #8) and possible development of previously unidentified sites (Ruby and O'Brien Creeks) (Erdman 1947). These alternatives are listed below:

Site	Pool el (ft.msl)	Capacity (MW)	Av. Annual Energy Million Kwh
Combined Project			
Katka Cr.	1817	58.2	218
Rocky Cr.	1842	39.3	151
Ruby Cr.	1868	41.2	157
	TOTAL	138.7	526
Single Project			
Katka	1862	144.0	534

These represent the alternatives at the time of design of this study and during most of the data collection. Subsequent to a request from DNRC, the applicant provided a more detailed engineering analysis of the originally proposed alternatives and determined the most practical alternative developments to be as follows (HARZA 1980).

Site	Pool el (ft.msl)	Power Rating (MW)	Annual energy (million Kwh)
Two Dam Alternatives			
Katka	1817	50	214
Rocky Cr.	1868	80	327
	TOTAL	130	541
Kootenai Falls (lowered)	1990	125	449
Rocky Cr.	1857	59	246
	TOTAL	184	695
Single Dam Alternative			
High Katka	1862	138	546

The applicant's engineering analysis and design of alternative Kootenai River hydropower sites is summarized in Table 6.

Information collected for this report supports the applicant's decision to eliminate the O'Brien and Ruby Creek sites from further consideration. This information along with site-specific and reconnaissance-level data for the Katka 1817 (low Katka), Katka 1862 (high Katka), Rocky Creek 1868, Ruby Creek 1868,

Table 6.
CHARACTERISTICS OF KOOTENAI RIVER HYDROPOWER ALTERNATIVES*

Project	Dam Type	Est. Height (ft.)	Est. Length (ft.)	Gross Head (ft.)	Installed Capacity (MW)	Mean Annual Average Energy	Pool Elevation	Reservoir Length (Miles)	Railroad Relocation (ft.)	Total Cost ($ million)
Katka 1862	concrete gravity	410'	675'	81'	138 MW	546000 mwh	1862 ft.	18 mi.	80,400 ft	$382
Katka 1817	concrete gravity	367'	675'	36'	50 MW	214000 mwh	1817 ft.	8 mi.		$280
Rocky Cr. 1868	concrete gravity	198'	700'	51'	80 MW	327000 mwh	1868 ft.	11 mi.		$195
Alternative total					130 MW	541000		19 mi.	80,400 ft	$475
Rocky Cr. 1857	concrete gravity	185'	700'	40'	59 MW	246000 mwh	1857 ft.	10 mi.		$166
Kootenai Falls 1990	concrete gravity	+20'	925'	79-96'	125 MW	449000 mwh	1990 ft.	2.3 mi.		$225
Alternative total					184 MW	695000		12.3 mi.	45,200 ft	$391

*SOURCE: (Harza 1980)

and O'Brien Creek 1917 alternatives is presented in the final portion of the report.

Site Specific Engineering Data

Detailed engineering information (ie. dam design, railroad relocation) for the alternates is available in a report titled "Alternative Power Sites on the Kootenai River" (HARZA 1980) and is not given here. Instead, a brief description of the salient engineering aspects of each project is given.

In general, each of the sites is located on a constricted, bedrock-controlled reach of the lower Kootenai River. The Ruby Creek site is an exception in that it is located in a broad valley bottom with the left (looking downstream) abutment in fractured bedrock and the right abutment in alluvium and colluvium, with bedrock depth and extent uncertain.

Civil Structures

The proposed civil structures for the different alternatives at any one site differ only in the amount of head to be developed. Characteristics of the proposed dams are given in Table 6. The estimated great depth to bedrock at the Katka site would require a very large dam in comparison to the amount of head developed. Katka (1817) would require a 367 foot high structure to develop 36 feet of head (HARZA 1980). Analysis of the alternative types of structures indicated the least costly option would be a concrete-gravity dam with integral spillway and power station. This design would involve construction of a large diversion tunnel capable of passing 26,000 cfs. Figures 14 and 15 show the proposed designs for the Katka 1817 and 1862 alternatives.

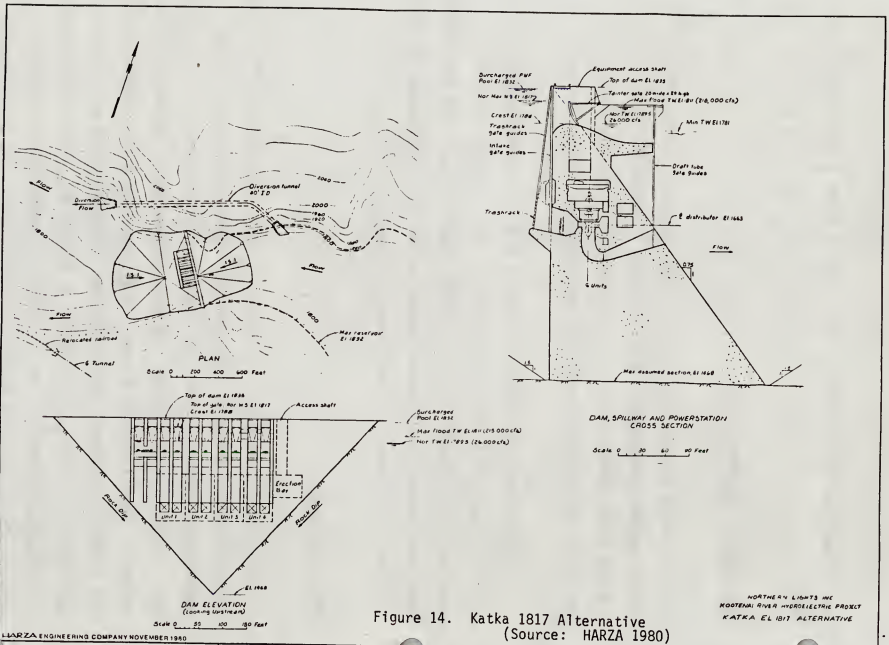

Figure 14. Katka 1817 Alternative
(Source: HARZA 1980)

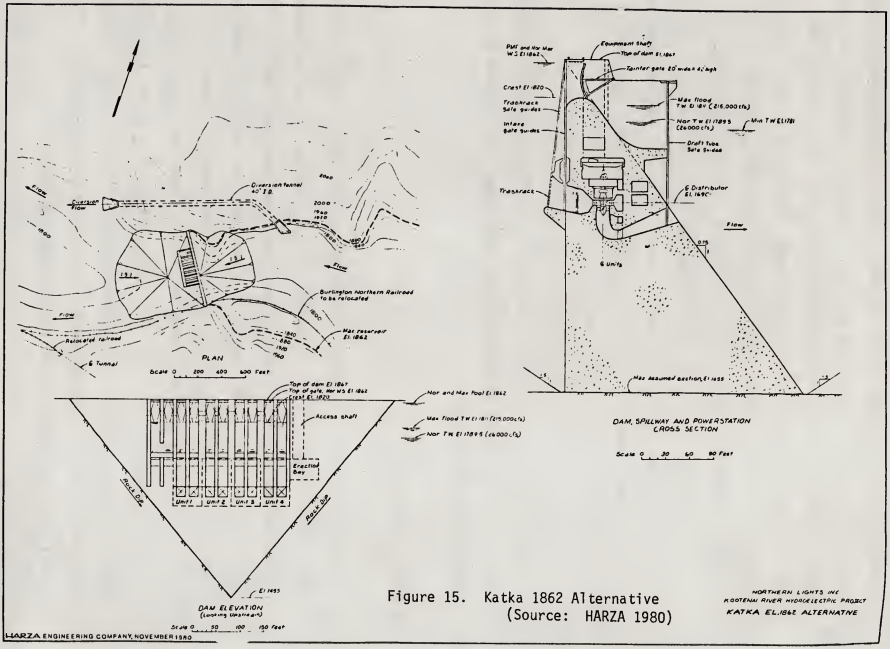

Figure 15. Katka 1862 Alternative
(Source: HARZA 1980)

As with the Katka site, the proposed alternative developments for the Rocky Creek Site (1857 and 1868) are similar and differ mainly in amounts of head that would be developed. However, the bedrock is thought to be at shallower depth than at Katka and permits greater flexibility in site layout (HARZA 1980). The least costly alternative at Rocky Creek would require excavation of a forebay on the right bank to lead headwater to a power station which would nearly parallel the natural right bank of the river (see Figure 16). The concrete-gravity dam with its spillway gates would extend across the left portion of the river at roughly a 58 degree angle to the power station. A diversion tunnel with the capacity to pass 26,000 cfs would be constructed on the right bank to pass river flow during construction (HARZA 1980).

HARZA did not prepare detailed layouts for the Ruby Creek and O'Brien Creek sites. For the purposes of this report it was assumed that they would be low, concrete-gravity structures.

Railroad Relocation

Because of the close proximity of the Burlington Northern Railroad to the Kootenai River between Troy and the Montana-Idaho border, two of the proposed alternatives would require extensive railroad relocation (See Figures 17 and 18). The required railroad relocations for Katka 1862 would be approximately the same as for the combination of Katka 1817 and Rocky Creek 1868. The principal feature of this relocation would be a 52,200 foot tunnel rising at 0.11% grade eastbound. This would be the longest railroad tunnel in the United States. The relocation would eliminate the present Leonia siting. The former Katka siding would be restored and the Yakt siding would be relocated. Five new bridges would be required for stream crossings (HARZA 1980).

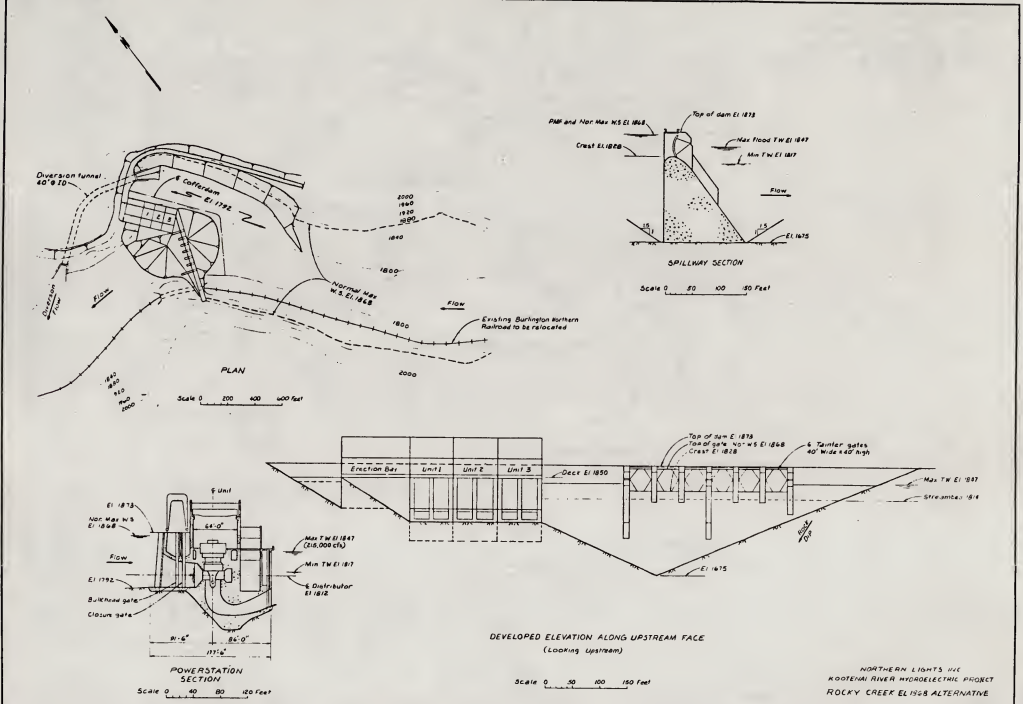

Figure 16. Rocky Creek 1868 Alternative (Source: HARZA 1980)

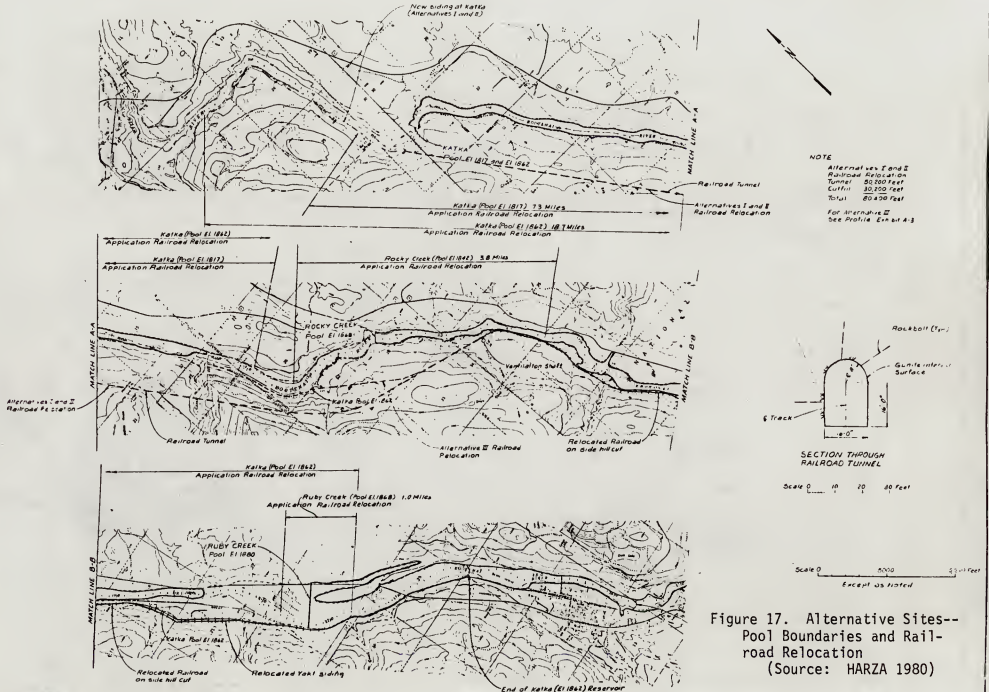

Figure 17. Alternative Sites--Pool Boundaries and Railroad Relocation (Source: HARZA 1980)

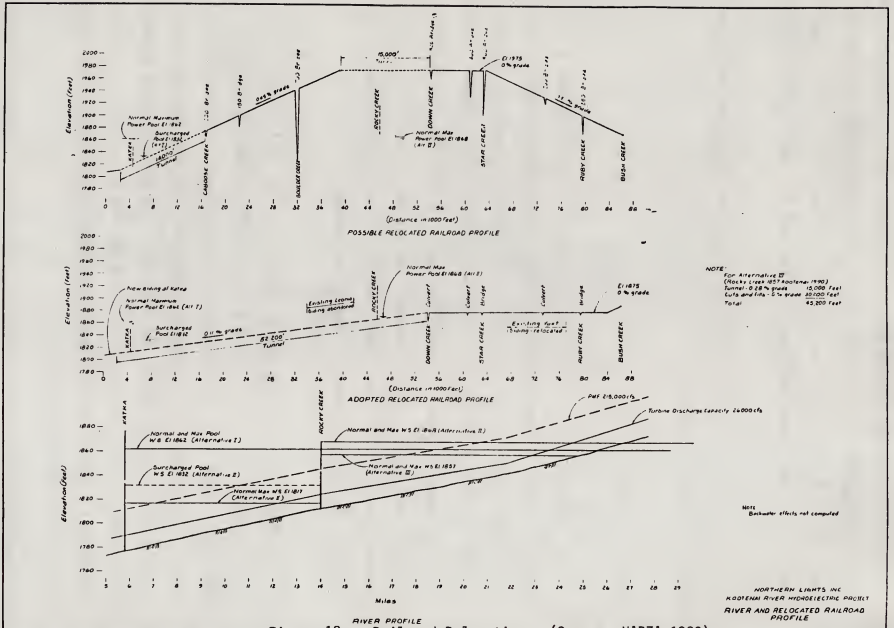

Figure 18. Railroad Relocation (Source: HARZA 1980)

The relocation requirements for the Rocky Creek 1857-Kootenai Falls 1990 two-dam alternative are much shorter than either alternative involving the Katka site. A tunnel 15,000 feet long would be required at Rocky Creek, along with another 4,000 feet of relocation at the Kootenai Falls 1990 site (HARZA 1980).

Either the Ruby Creek 1868 or the O'Brien Creek 1917 sites would require approximately one to two miles of railroad relocation.

Reservoir Pools

The length of reservoir for each alternative is given in Table 6. Generally, in the vicinity of the bedrock-confined reaches, the high valley side-slope angle would restrict the lateral extent of reservoir backwaters. In alluvial reaches where the river is less confined, the pool extent would be greater. Figure 17 shows the pools that would be created. Pool boundary estimates are based on simple straight-line extrapolation of estimated reservoir operating levels on river profiles. Without the benefit of backwater curve analysis, the estimates are neccessarily approximate.

Exhibit 1 (Generalized Surficial Geology) depicts pool boundaries at 1:24,000 scale. For clarity, only the Katka 1862, Rocky and Ruby Creek 1868, and O'Brien Creek 1917 pool boundaries are delineated. The Low Katka (1817) pool would lie just inside the High Katka (1862) pool and terminate about seven miles upstream from the dam in the vicinity of the gaging station at Leonia. The Low Rocky Creek (1857) pool would lie just inside the High Rocky Creek (1868) pool boundary and would end about two miles downstream of the Highway 2 bridge on the Kootenai River.

IV. Surficial Geology of Study Area

Pleistocene History

Pleistocene glaciation and subsequent fluvial action have produced the landforms and surficial deposits within the study area. During the Pleistocene, continental glaciation eroded and deposited vast quantities of glacial drift and outwash in the study area. Ice was at least 2,500 ft. thick in the Libby area and probably about the same thickness in the study area (Alden 1953). The exact chronology and sequence of glacial events in northwestern Montana has yet to be determined.

Glacial drift deposited in the study area consists primarily of poorly sorted till with subordinate sand and gravel and discontinous lenses of sand and silt. Glaciofluvial and ice-contact deposits resulting from melting of the ice sheet are widespread in the study area.

Periodically, water was ponded by a lobe of ice in the Purcell Trench west of the study area, forming glacial Lake Kootenai in the valleys of the Kootenai River and its tributaries (Alden 1953). The lake level reached 2600 ft msl and lacustrine beds were deposited. Remnants of these lakebeds are evident in the Libby and Lake Creek - Bull Lake valleys, and may be present on the high terraces flanking the study area.

Deglaciation of the area approximately 10,000 yrs. ago initiated downcutting of the Kootenai River bed and formation of a set of river terraces. These are particularly well-developed between the Yaak River mouth and Troy at elevations of 2200 and 2500 ft. (Dahlem 1959). This downcutting (probably in response to a change in base level, stream regimen and isostatic adjustment) produced narrow

constricted canyons where the post-glacial bedrock relief was high, and wider alluvial reaches where bedrock relief was low.

Surficial Geology

Generalized surficial geology of the study area is presented in Exhibit 1. The reconnaissance level 1:24,000 - scale map was prepared in cooperation with GeoServices West (O'Haire and Bateridge 1980). It is based on review of existing geology and soils literature, a walking traverse of the river along the railroad tracks from Leonia to Katka, limited field inspection of each dam site, and review of false-color infrared photography of the study area. Particular emphasis was placed on identification of reservoir boundary materials. Well logs were reviewed to provide information on groundwater and subsurface materials. Field work was done in November of 1980.

A description of map units is as follows:

Holocene Alluvium:

This consists of relatively well-sorted silt, sand, gravel, and cobbles reworked from glacial deposits by streams. These deposits occupy the beds of existing water courses, mid-channel islands, point bars and the fringe of study area river channels. Alluvium varies widely in composition but generally tends to be coarse near the present channel and has a surficial fiftieth percentile (intermediate) diameter generally between 30 and 150mm. The alluvium is generally more permeable than glacial deposits. Well yields from similar deposits in the Libby valley range from 100 to 500 gal/min (Boetcher and Wilke 1978). For the study area, well yields of 15-50 gal/min. are common (see well logs, Appendix B).

Quaternary Glacial Deposits:

These are undifferentiated glacial till and glacio-fluvial materials which consist of poorly-sorted mixtures of boulders, cobbles, gravel, silt and clay. Glacial deposits overlie Precambrain metasediments and probably reach a thickness of several hundred feet near Troy. The exact thickness is unknown because wells do not completely penetrate the glacial deposits. Well log 26 (Appendix B) indicates a continous depth of glacial materials greater than 144 ft.

In the vicinity of the axis of the Ruby Creek Dam, well log 16 indicates a thickness of at least 200 ft of glacial materials. Other shallower wells in the area do not penetrate the surficial deposits.

Well log 18 indicates a subsurface promontory of bedrock covered with six ft. of sand about 1800 ft. upriver of the proposed Ruby Creek dam axis. Significant glacial deposits are not found within the proposed pool boundaries downstream of the confluence of the Kootenai and Yaak Rivers. Wells tapping glacial deposits commonly have yields in the range of 5 to 35 gal/min.

Quaternary Lakebeds

Lacustrine deposits of silt and clay are buff in color and thinly laminated. Laminae are commonly 1/8 in. or less in thickness. As previously mentioned, lake beds are not extensively exposed in the study area. Two occurrences are indicated on Exhibit 1. Lake silts are highly impermeable and no wells in the area draw water from lake bed deposits.

Precambrian Metasediments

Almost all bedrock in the study area consists of Precambrian metasediments of the Belt Supergroup. These rocks consist of limestone, calcareous argillite, siltite, sandstone and quartzite with local intrusions of Purcell sill. These metasediments as mapped by Johns (1970), Erdman (1947), Gibson (1948) and Miller (1973) belong to the Prichard and Wallace Formations. The engineering integrity of exposed bedrock varies primarily as a function of proximity to local faults and folds. Generally the bedrock exposures in the study area are restricted to cliffs adjacent to the river. Minor (10 to 50 ft. horizontal extent) colluvial deposits are found at the base of most bedrock exposures and consist of coarse talus.

Reservoir Boundary Materials

Katka Creek 1862 and 1817

Construction of the High Katka Dam with a crest elevation of 1862 ft. would create a reservoir approximately 18 miles long, extending to the vicinity of Troy. Of this length, 10.5 miles would be within a bedrock gorge extending upstream to the mouth of the Yaak River. Pool boundary materials in this section would be mainly bedrock and colluvium. Two significant areas of colluvium (probably fault-related) are shown on Exhibit 1 and might pose stability problems if saturated.

From the Yaak River mouth upstream, the Kootenai Valley widens, with bedrock and glacial deposits being the dominant pool boundary materials. Between Troy and the Yaak River, extensive low-lying glacial deposits would be submerged or saturated by shallow groundwater caused by the reservoir. A pool at 1862 feet would inundate most of the Quaternay alluvium known to exist within the study area.

A Low Katka (1817) dam would create a pool about eight miles long extending to the vicinity of the USGS gaging station at Leonia. The pool boundary material would consist almost entirely of bedrock and colluvium.

Rocky Creek 1868 and 1857

The Rocky Creek 1868 pool would be approximately 11 miles long and extend to near the mouth of Lake Creek. Of this, the 3.5 miles extending to the Yaak River mouth would be in a bedrock gorge. The pool boundary upstream from the

Yaak River would lie mainly in glacial deposits. In areas where the pool boundary lies adjacent to low-lying glacial deposits or recent alluvium, shallow ground water could be anticipated.

The Rocky Creek 1857 pool would have much the same boundary materials as Rocky Creek 1868.

Ruby Creek 1868

The Ruby Creek 1868 pool would extend approximately five miles upstream to the mouth of Lake Creek. The pool would have glacial deposits on one side or the other for its entire length. Scott Island and the point bar immediately downstream would be submerged.

O'Brien Creek 1917

A dam at O'Brien Creek (1917) would create a pool about 4.7 miles long, extending approximately to the base of Kootenai Falls (in the vicinity of tailrace outlet for proposed Kootenai River hydroelectric project). The upper one-third would be in the bedrock gorge below Kootenai Falls; the lower two-thirds would be in glacial sediments. Low-lying areas adjacent to the pool could become saturated and experience shallow groundwater.

A summary of estimated reservoir boundary materials for each alternative is provided below.

Table 7. Reservoir Shoreline Materials - percentages of each map unit per/alternative

Pool (mi)	Bedrock	Glacial Deposit	Lakebed Deposit	Alluvium	Pool Length
Katka 1862	75	20	1	5	18
Rocky Creek 1868 & 1857	70	20	0	10	11
Ruby Creek 1868	30	45	5	20	5
O'Brien Creek 1917	10	50	0	10	5

Potential Areas of Elevated Groundwater

Where materials adjacent to the pool boundaries consist of relatively permeable outwash till and alluvium, it is reasonable to assume that groundwater levels eventually would rise to approximately the elevation of the pool boundary (Davis and Deweist 1966). On the basis of topography and distribution of surficial deposits, it is possible to broadly identify areas of potential year-round shallow (10 ft. or less below ground surface) groundwater. Because of the complex stratigraphy (interbedding of sands, gravels, and silt-clay levels, as indicated on study area well logs) of glacial deposits and variations in local water balance, precise delineation of reservoir-induced elevated groundwater areas was not possible in this reconnaissance-level investigation.

The major areas where shallow groundwater could be anticipated are:

1) the floodplains and low terraces along the Kootenai River upstream from the mouth of the Yaak River,

2) the low-lying areas in the vicinity of the Kootenai Vista subdivision (adjoining the Ruby Creek site) and upstream of the Ruby Creek site,

3) the area of Troy, Montana (much of Troy is at an elevation of 1880 to 1888 ft. msl).

The areal extent of shallow groundwater depends on the pool elevation and on the elevation and composition of reservoir boundary materials. The percentage of total reservoir shoreline with adjacent areas of potential shallow year-round ground water is summarized below for each alternative project.

Table 8. Estimated extent of shallow groundwater for reservoir pools.

Pool	Elevation (ft msl)	% Shoreline with adjacent areas of potential shallow Groundwater	Pool Length (mi)
Katka	1862	15%	18
Katka Creek	1817	5%	8
Rocky Creek	1868	30%	11
Ruby Creek	1868	40%	5
O'Brien Creek	1917	30%	5

Geology of Dam Sites

The following discussion is based on limited field investigation of the sites and on review of literature pertaining to them. Erdman (1947) investigated the Katka and Rocky Creek sites and his mapping provides the best

geologic detail for determining the relative suitability of these sites. The descriptions of the Katka and Rocky Creek sites are based on his work. More recently, HARZA (1980) provided reconnaissance-level engineering and geologic data for each of the sites, and described potential engineering problems at each. The work of Kirkham (1939), Gibson (1948), Pardee (1950), Dahlem (1959), Johns (1970) and Miller (1973) also was reviewed.

Katka Creek Site

The Katka site is located near a sharp bend in the Kootenai River about three miles west of the Montana/Idaho border and one mile upstream from the old Katka railway station. Bedrock in the dam site area consists mainly of the Prichard Formation and Moyie Sill, with minor amounts of Wallace Formation present. Figure 19 shows dam site geology as mapped in detail by Erdman (1947).

The Prichard Formation at this site is quartzite and argillite and is locally contact metamorphosed. In the immediate vicinity of the dam site, beds strike north-northwest and dip 50 to 70 degrees northeast.

A major feature of the dam site is a large sill about 700 ft. thick which has intruded into the gray quartzite of the Prichard Formation. The top of the sill dips about 73 degrees east, and beds near the base dip 52 degrees to 57 degrees east. The variation in dip gives the mass a wedge-shaped cross-section and suggests that it may "pinchout" with depth. The sill strikes north 25 to 30 degrees west and as described by Erdman (1947) is a fine-to-coarse-grained, dark-green hornblendite or hornblende gabbro. The sill is more resistant to erosion than quartzitic Prichard rocks and forms a ridge in the vicinity of the dam site.

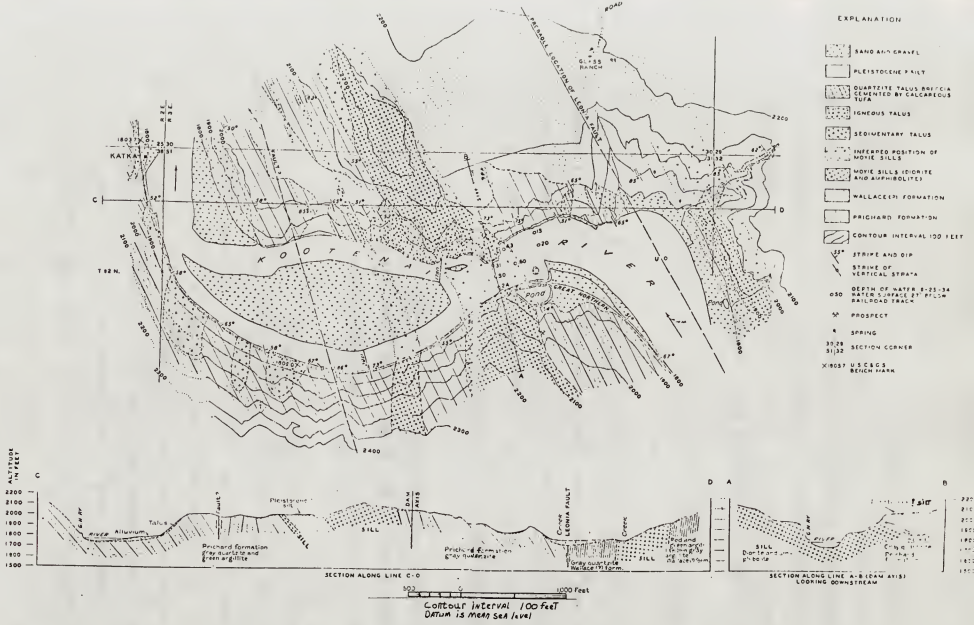

Figure 19. Geologic Map and Cross-sections of Katka Dam Site
(Source: Erdman 1947)

Erdman estimated that the sill has a specific gravity of about 3, that the ultimate crushing strength of the rock was about 25,000 PSI, and that the sill was relatively unaffected by weathering.

The following joints were observed (by Erdman) in the abutments:

Table 9. Joint Pattern at Katka Dam Site.

Right Abutment		Left Abutment	
Strike	Dip	Strike	Dip
N 68 degrees W	62 degrees W	N 42 degrees W	48 degrees W
N 28 degrees W	62 degrees E		
N 64 degrees E	88-90 degrees S	N 65 degrees E	vertical
N 80 degrees E	64 degrees S	N 58 degrees E	69 degrees N
N 47 degrees E	67 degrees N		

Joints in the right abutment are closely spaced (about one to four feet apart). Joints in the left abutment are spaced at wider intervals (about 20 ft.). Intervening areas are thorougly jointed by a second set of fractures dipping NW and W at low angles--Erdman considers these to be older joints. The joint patterns in both abutments indicate two sets of master joints; the first set strikes N 42 degrees W and dips 48 degrees W, and the second set strikes N 65 degrees E and dips nearly vertical. The first set strikes normal to the direction of stream flow, which is unfavorable for leakage, but dips in a direction favoring leakage. However, these joints are not closely spaced and percolation through them probably would not be as effective as it would be along joints of the second set, parallel to the direction of streamflow.

There are several faults of possible engineering significance at the Katka site. Most significant among these is the Leonia Fault which lies about 1,500 ft. east of the dam site and strikes to the northwest (see figure 19). As indicated earlier, this fault would require detailed geotechnical investigation to determine last age of movement and to aid in estimation of a design earthquake for a structure at Katka.

Erdman estimated the channel cross-section and dam section to be as indicated in the lower right A-B section of figure 19. At the time of survey (September 1934) the water surface width was 280 feet and maximum water depth was 50 ft. Erdman further estimated that a masonry or concrete dam at the site would be located entirely within the Moyie Sill and would require a foundation about 60 feet deep.

Rocky Creek Site

The Rocky Creek or Tunnel No. 8 Dam site is located about 1.5 miles east of the Montana/Idaho border and two miles upstream from Leonia, Idaho. Rocks of the Wallace Formation crop out at the dam site. Site geology as mapped by Erdman is shown in figure 20.

Here, the Wallace Formation is a thin-bedded, well-jointed, argillaceous limestone with smooth, open bedding surfaces that weather readily and contribute to the low rock strength at the site. Erdman estimated rock hardness at 4 to 5 (mohs hardness scale), the specific gravity at 2.7 and ultimate crushing strength to be 8,000 to 10,000 PSI.

Beds of the Wallace Formation dip steeply downstream at the site. A fault just south of the railroad tunnel (see figure 20) strikes west and dips 43

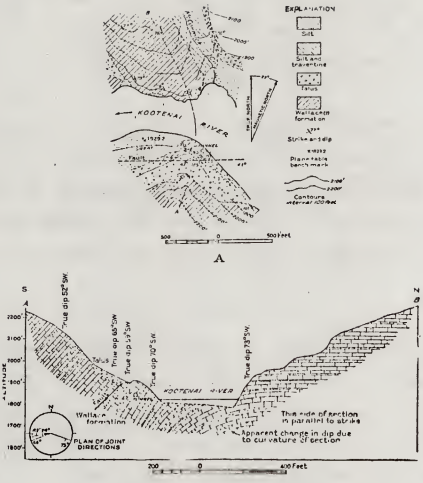

Figure. 20. Geologic Map and Cross-section of Rocky Creek Dam Site. (Source: Erdman 1947)

degrees S. The gouge zone associated with the fault is about three feet thick. Beds adjacent to the fault on the north strike N 33 degrees W and dip 59 degrees W. Those on the south side strike N 31 degrees W and dip 65 degrees W. Erdman reasoned that this fault, with its thick zone of soft clayey gouge, is an element of structural weakness which makes the bedrock spur (left or south abutment) unsuitable for the abutment of a high dam.

The dam section at the site is shown in figure 20. The section is narrow (360 ft.) and constricted compared with the normal width of the river valley, and causes the water surface to rise rapidly with increasing discharge during spring floods. Erdman suggested that only small amounts of alluvium are present in the channel and that the depth to bedrock was not much greater than 40 feet.

Both abutments at the site would be located in steeply dipping rocks of the Wallace Formation. Because of the fault in the left abutment, the bearing strength of the two abutments would be unequal. Erdman (1947) concluded that: (1) the left abutment fault precludes the possibility of constructing a dam higher than 20 ft. at the site; (2) if a high dam were considered, the spur through which the railroad tunnel passes should be removed and the left abutment of the dam be rested in rock south of the fault (the fault would still pose problems); and (3) proximity of the site to the fault requires consideration of some type of flexible design, but large spillway requirements operate against such a design. Erdman considered the Rocky Creek site economically and geologically unsuitable for development.

Ruby Creek Site

The Ruby Creek Site is located about one mile downstream of the U.S. Highway 2 bridge across the Kootenai River and immediately upstream of the Kootenai

Vista Subdivision. At the site the valley bottom is about one mile wide and the channel is dominantly alluvial. Glacial deposits as mapped on Exhibit 1, are widespread and outcrops of bedrock are limited to the area of the left abutment at the dam site.

Bedrock exposed in a railroad cut approximately 150 ft. long near the left abutment is in the Wallace Formation, and generally strikes N 60 to 70 degrees W and dips 50 to 60 degrees SW. The rock is a thinly-laminated (1/2 to 2 in.) highly fractured, highly weathered calcareous arigillite to argillaceous limestone. The degree of jointing and fracturing made precise measurements of joint patterns difficult but it appears that there are at least two dominant and two subsidiary joint sets in the outcrop. A portion of the observed joints may actually be well-developed fracture cleavage related to the axis of a small anticline which trends N 70 degrees W and lies about 1/2 mile east of the site.

As with the Katka and Rocky Creek sites, the Leonia fault passes within one mile of the site (Johns 1970). Two east-west to northwest trending subsidiary faults adjoin the Leonia fault and cross the river at right angles about two miles downstream (north) of the damsite. These faults intersect the O'Brien Creek fault, which runs parallel to the river approximately 2.5 miles from the Ruby Creek Site.

Bedrock as described in well log #18 may be associated with a narrow topographic promontory of limited extent (see Exhibit 1). Elsewhere in the vicinity of the proposed dam axis, glacial deposits reach a minimum thickness of 200 ft. (see well log #16). The physical character of bedrock underlying the glacial materials is unknown, but based on the left abutment exposure and proximity of the dam axis to the axis of the previously mentioned anticline, it is likely to be weak and generally unsuitable as dam foundation material. Areal

extent and thickness of glacial deposits and the great length of the dam crest required to develop the site, contribute to the unfavorability of the site for dam construction.

O'Brien Creek Site

The O'Brien Creek site is located about one mile upstream of the city of Troy, Montana in a relatively narrow, bedrock-constricted reach of the Kootenai River (see Exhibit 1). This channel reach consists of both glacial materials and bedrock. Bedrock is exposed on the left abutment in a 30-foot cliff. The area of the right abutment appears to contain colluvial and glacial materials underlain by bedrock at an uncertain depth. An isolated bedrock knob crops out in the center of the channel along the proposed dam axis.

Bedrock exposed in the left abutment area is argillite of the Wallace Formation, and is of generally poor quality. The rock is thin-bedded in 1 -to-4-inch beds with locally thinner laminae. Bedding generally strikes N 15 to 20 degrees W and has dips near vertical. The rock is well-jointed with dominant patterns striking and dipping due E, 54 degrees SE and N 52 degrees E, 40 degrees N. Spacing on joints varies from about 2 in. to 2 ft.; talus at the base of the outcrop averages 3 in. by 2 in. by 6 in. About 100 feet north of its southernmost edge, the outcrop is cut by a local fault, which trends N 75 degrees W and dips approximately 59 degrees N. Rock type is the same on either side of the fault trace; the fault zone is about 1/2 ft. to 2 ft. wide and clayey gouge is present.

Upslope about 100 yards (west) of this outcrop, the rock type changes to a more quartzitic rock type. Here the section is largely covered with a thin veneer of colluvium or glacial drift, but shallow (less than five feet) bedrock

is apparent as one continues west to the contact with the Troy sanitary landfill. Geologic materials in the vicinity of the landfill, which is located on a terrace overlooking the O'Brien Creek Site, consist largely of glacio-fluvial deposits. These glacial materials appear to surround the outcrop which would form the left abutment of the dam. However, due to forest and soil cover, a detailed geotechnical investigation would be required to evaluate the lateral extent of bedrock in the left abutment area.

The poor quality of bedrock exposed at the site along with potential instability and leakage problems which could be caused by the glacial materials in the vicinity of the left abutment contribute to the unfavorability of the site.

FOOTNOTES

* On the annual peak-flow series, the 1.5 yr. RI event has a 66% chance (probability of occurring in any individual year or on the average, occurs twice in three years. Similarly, the 50 and 100 year RI events have .02 and .01 annual probabilities of occurrence, respectively. The 50 year event occurs twice in 50 years and the 100 year event occurs once in 100 years, on the average.

** The eight year period 1972-79 provides a period of record shorter than the 10 year minimum specified by the Water Resources Council (Guidelines for Determining flood flow frequency, U.S. Water Resources Council, Bulletin #17A, 1977). Data prodeuced through extrapolation of flood flow characteristics past a 15 to 20 year event may be tenuous.

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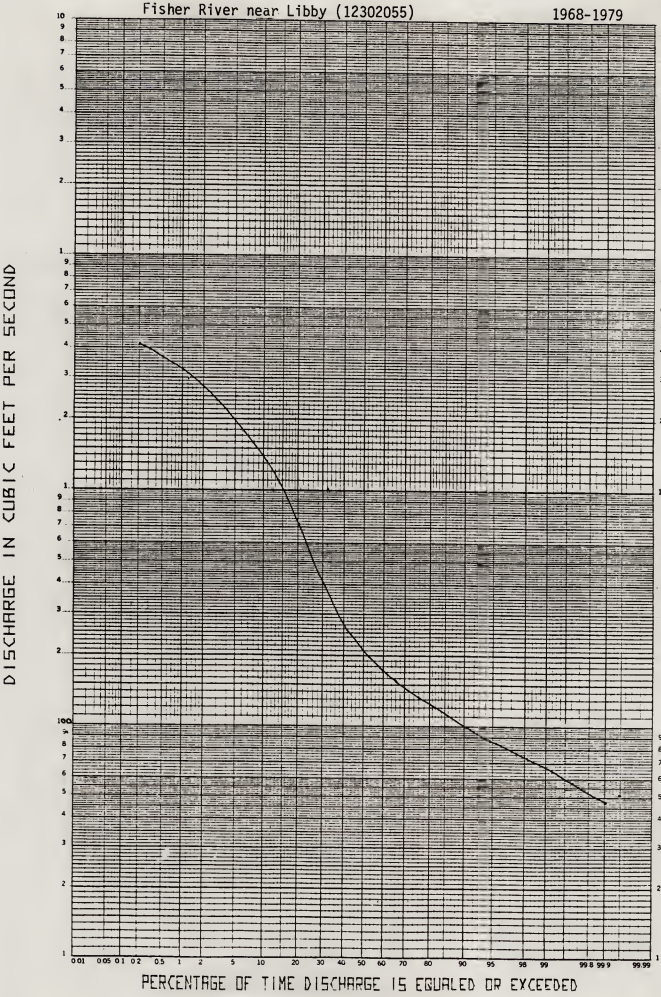
APPENDIX A.

Streamflow Characteristics


Fisher River near Libby (12302055)
1968-1979
DISCHARGE IN CUBIC FEET PER SECOND
PERCENTAGE OF TIME DISCHARGE IS EQUALED OR EXCEEDED
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99

STATION NUMBER 12302055

DURATION TABLE OF DAILY VALUES FOR YEAR ENDING SEPTEMBER 30

DISCHARGE, IN CUBIC FEET PER SECOND
MEAN
FISHER RIVER NEAR LIDEY, WA.

CLASS	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
YEAR	NUMBER OF DAYS IN CLASS																																		
1968								3	17	44	15	37	28	55	22	21	13	26	22	14	11	20	14	18	6										
1969									5	37	16	32	22	44	66	23	8	9	11	5	9	9	1	8	11	6	12	8	17	4		2			
1970						5	28	33	93	37	29	14	20	8	12	2	7	13	10	9	5	1	6	12	3	7	8	3							
1971							2	8	12	41	30	40	16	10	14	23	13	13	12	16	18	18	3	7	21	8	6	10	10	4	8	2			
1972							1	1	1	35	76	52	24	7	13	10	6	5	8	2	3	4	15	9	23	9	24	8	12	9	6	2	1		
1973					13	29	19	22	8	64	29	15	28	26	23	13	14	23	17	10	5	2		3	2										
1974							12	20	15	36	11	23	19	12	13	30	20	13	9	13	11	4	5	8	18	10	28	16	8	6	2	1		1	1
1975					1	1	4	15	49	76	39	32	24	16	12	5	5	4	4	7	9	4	6	10	19	5	8	4	6	4					
1976								3	30	19	31	33	37	42	31	21	13	12	5	10	14	10	11	13	5	10	5	7	3	1					
1977			1	1	1	9	17	37	59	41	113	11	6	3	6	14	14	10	4	7	7	4													
1978				1		2	9	44	13	70	36	29	18	15	9	11	4	3	7	5	16	11	7	15	19	7	7	2							
1979			1	2	17	45	62	40	30	11	10	6	4	6	4	4	9	10	18	7	13	8	3	16	5	5	3	4							

CLASS	VALUE	TOTAL	ACCUM	PERCT	CLASS	VALUE	TOTAL	ACCUM	PERCT	CLASS	VALUE	TOTAL	ACCUM	PERCT
0	0.0	0	4383	100.0	12	200.0	235	2292	52.3	24	1300.0	160	513	11.7
1	35.0	1	4383	100.0	13	230.0	232	2057	46.9	25	1600.0	58	353	8.0
2	41.0	2	4382	100.0	14	270.0	242	1825	41.6	26	1800.0	107	295	6.7
3	48.0	2	4380	99.9	15	320.0	195	1583	36.1	27	2200.0	62	188	4.2
4	56.0	25	4378	99.9	16	380.0	118	1388	31.7	28	2500.0	69	126	2.8
5	66.0	68	4353	99.3	17	440.0	129	1270	29.0	29	3000.0	30	57	1.3
6	77.0	134	4285	97.8	18	520.0	132	1141	26.0	30	3500.0	17	27	.6
7	91.0	264	4151	94.7	19	610.0	112	1009	23.0	31	4100.0	7	10	.2
8	110.0	237	3864	88.2	20	710.0	112	897	20.5	32	4800.0	1	3	
9	120.0	669	3627	82.8	21	830.0	104	785	17.9	33	5600.0	1	2	
10	150.0	330	2958	67.5	22	980.0	70	681	15.5	34	6600.0	1	1	
11	170.0	330	2628	60.0	23	1100.0	98	611	13.9					

VALUE EXCEEDED "P" PERCENT OF TIME

V95 =	90.0
V90 =	100.0
V75 =	140.0
V50 =	210.0
V25 =	550.0
V10 =	1400.0

FISHER-TIPPETT PLOTTING PAPER

N = 47

STATION 12302055

1 DAY LOW FLOW

PROBABILITY

0.995 0.99 0.95 0.90 0.80 0.50 0.20 0.1 0.04 0.02 0.01 0.005

1000

100

10

1.005 1.01 1.05 1.11 1.25 2 5 10 25 50 100 200

RECURRENCE INTERVALS

THE FOLLOWING SYMBOLS MAY APPEAR IN THE PLOT

X - AN INPUT DATA VALUE

* - A CALCULATED VALUE

U - A CALCULATED VALUE AND ONE DATA VALUE AT SAME POSITION

2 - TWO INPUT DATA VALUES PLOTTED AT SAME POSITION

3 - THREE INPUT DATA VALUES PLOTTED AT SAME POSITION

A - A CALCULATED VALUE AND TWO DATA VALUES AT SAME POSITION

B - A CALCULATED VALUE AND THREE DATA VALUES AT SAME POSITION

[redacted] N = STATION 12302055

12 MON PERIOD ENDING SEPTEMBER 30

1 DAY LOG VALUE

INPUT DATA (ZERO VALUES OMITTED)

106.000	116.000	80.000	90.000	80.000	62.000	88.000	60.000	114.000	35.000
45.000	55.000								

MEAN = 77.585

VARIANCE = 710.992

STANDARD DEVIATION = 26.664

SKEWNESS = -0.009

STANDARD ERROR OF SKEWNESS = 0.637

SERIAL CORRELATION COEFFICIENT = 0.120

COEFFICIENT OF VARIATION = 0.344

MEAN LOGS = 1.865

VARIANCE LOGS = 0.027

STANDARD DEVIATION LOGS = 0.164

SKEWNESS LOGS = -0.564

STANDARD ERROR OF SKEWNESS LOGS = 0.637

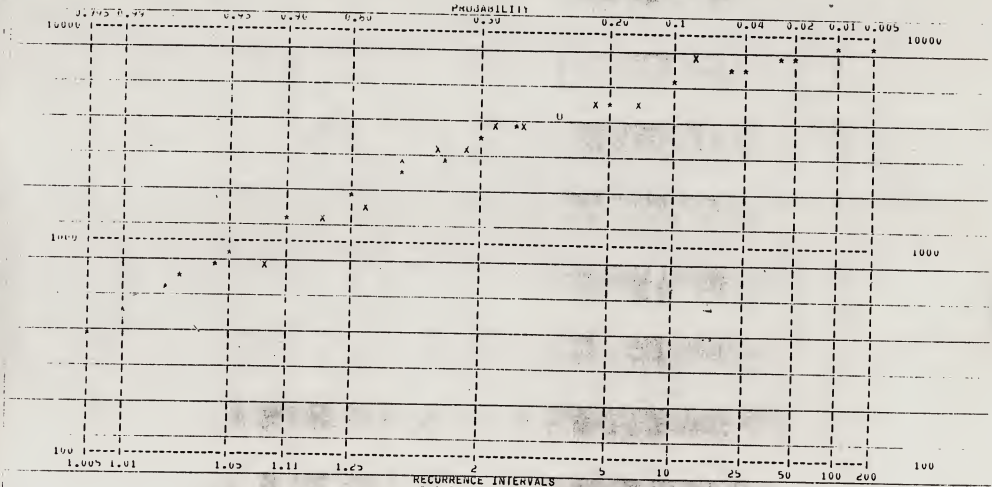
SERIAL CORRELATION COEFFICIENT LOGS = 0.179

COEFFICIENT OF VARIATION LOGS = 0.088

NON EXCEED PROB	RECURRENCE INTERVAL	PARAMETER VALUE
0.0100	100.00	25.909
0.0200	50.00	30.046
0.0500	20.00	37.094
0.1000	10.00	44.223
0.2000	5.00	53.951
0.5000	2.00	75.714
0.8000	1.25	100.884
0.9000	1.11	114.950
0.9600	1.04	130.287
0.9800	1.02	140.233
0.9900	1.01	149.122

STATION 12302055

1 DAY NOV VALUE



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N =

STATION 12302055

[redacted] PERIOD ENDING SEPTEMBER 30

[redacted] VALUE

INPUT DATA (ZERO VALUES OMITTED)

1450.000	4650.000	2790.000	4480.000	4820.000	1520.000	7280.000	3480.000	3700.000	784.000
2520.000	2490.000								

MEAN = 3510.333

VARIANCE = 3216807.00

STANDARD DEVIATION = 1793.507

SKEWNESS = 0.701

STANDARD ERROR OF SKEWNESS = 0.637

SERIAL CORRELATION COEFFICIENT = -0.299

COEFFICIENT OF VARIATION = 0.542

MEAN LOGS = 3.451

VARIANCE LOGS = 0.075

STANDARD DEVIATION LOGS = 0.274

SKEWNESS LOGS = -0.725

STANDARD ERROR OF SKEWNESS LOGS = 0.637

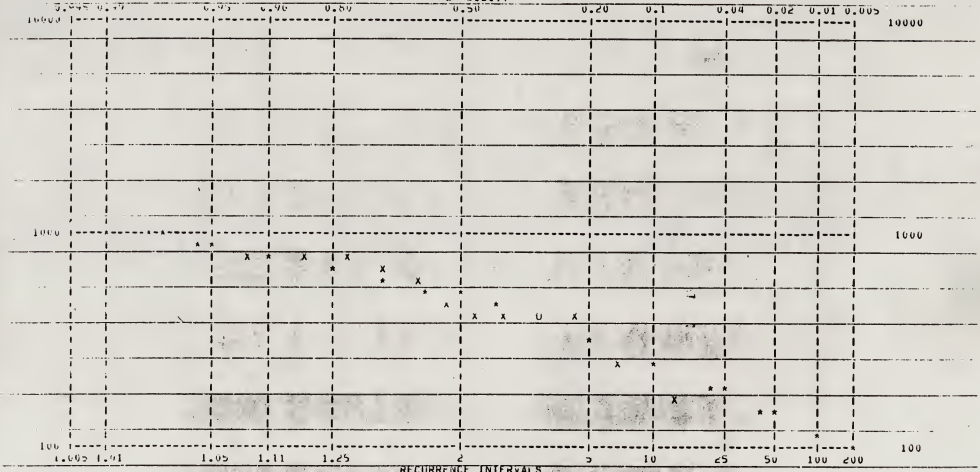
SERIAL CORRELATION COEFFICIENT LOGS = -0.270

COEFFICIENT OF VARIATION LOGS = 0.079

EXCEEDANCE PROB	RECURRENCE INTERVAL	PARAMETER VALUE
0.9900	1.01	471.025
0.9500	1.05	894.292
0.9000	1.11	1218.051
0.8000	1.25	1718.964
0.5000	2.00	3045.684
0.2000	5.00	4847.187
0.1000	10.00	5938.457
0.0400	25.00	7172.414
0.0200	50.00	7986.254
0.0100	100.00	8716.770
0.0050	200.00	9375.848

STATION 12302055

365 DAY LOW VALUE



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# = A CALCULATED VALUE AND TWO DATA VALUES AT SAME POSITION
@ = A CALCULATED VALUE AND THREE DATA VALUES AT SAME POSITION

NEAR LIBERTY, TX. STATION 12302055

12 MON PERIOD ENDING SEPTEMBER 30

365 DAY LOW VALUE

INPUT DATA (ZERO VALUES OMITTED)

426.000	565.000	400.000	732.000	815.000	250.000	804.000	472.000	561.000	169.000
925.000	341.000								

MEAN = 504.500

VARIANCE = 44571.515

STANDARD DEVIATION = 211.234

SKEWNESS = 0.078

STANDARD ERROR OF SKEWNESS = 0.637

SERIAL CORRELATION COEFFICIENT = -0.301

COEFFICIENT OF VARIATION = 0.409

MEAN LOGS = 2.668

VARIANCE LOGS = 0.042

STANDARD DEVIATION LOGS = 0.205

SKEWNESS LOGS = -0.838

STANDARD ERROR OF SKEWNESS LOGS = 0.637

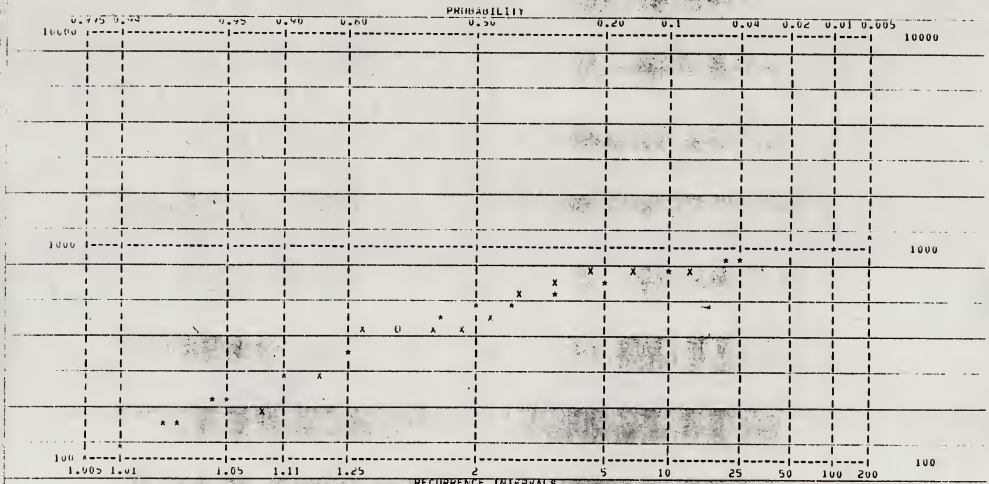
SERIAL CORRELATION COEFFICIENT LOGS = -0.286

COEFFICIENT OF VARIATION LOGS = 0.077

NON EXCEED PROB	RECURRENCE INTERVAL	PARAMETER VALUE
0.0100	100.00	117.374
0.0200	50.00	144.874
0.0500	20.00	194.447
0.1000	10.00	247.277
0.2000	5.00	322.356
0.5000	2.00	496.352
0.8000	1.25	696.667
0.9000	1.11	804.124
0.9600	1.04	915.822
0.9800	1.02	983.619
0.9900	1.01	1041.541

STATION 12302055

365 DAY HIGH VALUE



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STATION 12302055

12 RUN PERIOD ENDING SEPTEMBER 30

365 DAY HIGH VALUE

INPUT DATA (ZERO VALUES OMITTED)

425.000	648.000	400.000	732.000	813.000	250.000	804.000	472.000	561.000	169.000
428.000	541.000								

MEAN = 509.500

VARIANCE = 43581.593

STANDARD DEVIATION = 208.754

SKEWNESS = 0.076

STANDARD ERROR OF SKEWNESS = 0.637

SERIAL CORRELATION COEFFICIENT = -0.301

COEFFICIENT OF VARIATION = 0.409

MEAN LOGS = 2.688

VARIANCE LOGS = 0.042

STANDARD DEVIATION LOGS = 0.205

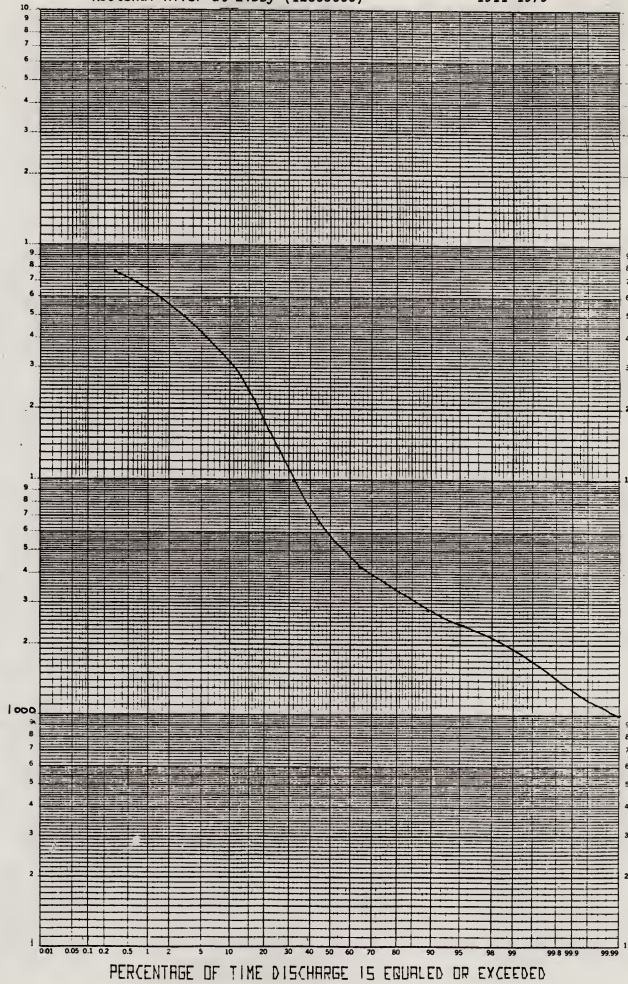
SKEWNESS LOGS = -0.836

STANDARD ERROR OF SKEWNESS LOGS = 0.637

SERIAL CORRELATION COEFFICIENT LOGS = -0.286

COEFFICIENT OF VARIATION LOGS = 0.077

EXCEEDENCE PROB	RECURRENCE INTERVAL	PARAMETER VALUE
0.9900	1.01	117.374
0.9500	1.05	194.447
0.9000	1.11	247.271
0.8000	1.25	324.556
0.5000	2.00	496.552
0.2000	5.00	696.667
0.1000	10.00	804.124
0.0400	25.00	915.422
0.0200	50.00	983.617
0.0100	100.00	1041.941
0.0050	200.00	1091.218


Kootenai River at Libby (12303000) 1911-1979
DISCHARGE IN CUBIC FEET PER SECOND
1000
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
PERCENTAGE OF TIME DISCHARGE IS EQUALED OR EXCEEDED

STATION NUMBER 12303000

DURATION TABLE OF DAILY VALUES FOR YEAR ENDING SEPTEMBER 30

DISCHARGE-(CFS)
MEAN
KOOTENAI RIVER AT LIBBY, MT.

CLASS	VALUE	TOTAL	ACCUM	PERCT	CLASS	VALUE	TOTAL	ACCUM	PERCT	CLASS	VALUE	TOTAL	ACCUM	PERCT
0	0.0	0	22280	100.0	12	4900.0	1712	13434	60.3	24	28000.0	511	2734	12.2
1	1000.0	6	22280	100.0	13	5700.0	1448	11722	52.6	25	32000.0	529	2223	9.9
2	1200.0	12	22274	100.0	14	6600.0	1095	10274	46.1	26	37000.0	545	1694	7.6
3	1300.0	30	22262	99.9	15	7600.0	986	9179	41.2	27	43000.0	450	1149	5.1
4	1500.0	102	22232	99.8	16	8800.0	859	8193	36.8	28	50000.0	286	699	3.1
5	1900.0	210	22130	99.3	17	10000.0	986	7334	32.9	29	58000.0	215	413	1.8
6	2100.0	496	21920	98.4	18	12000.0	727	6348	28.5	30	67000.0	123	198	.8
7	2400.0	1415	21424	96.2	19	14000.0	563	5621	25.2	31	77000.0	55	75	.3
8	2800.0	1402	20009	89.8	20	16000.0	536	5038	22.6	32	89000.0	11	20	
9	3200.0	1658	18607	83.5	21	18000.0	655	4502	20.2	33	100000.0	8	9	
10	3700.0	1859	16949	76.1	22	21000.0	487	3847	17.3	34	120000.0	1	1	
11	4300.0	1056	15090	67.7	23	24000.0	626	3360	15.1					

VALUE EXCEEDED "P" PERCENT OF TIME

V95 = 2500.0
V90 = 2800.0
V75 = 3600.0
V70 = 4100.0
V50 = 6100.0
V25 = 14000.0
V10 = 32000.0

19[illegible] 12 MON PERIOD ENDING SEPTEMBER 30

1 DAY HIGH VALUE

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[redacted] ENDING SEPTEMBER 30

VALUE

PUT DATA (ZERO VALUES OMITTED)

72500.000	36100.000	77300.000	56900.000	54000.000	120000.000	65000.000	75600.000	79800.000	60500.000
72900.000	69200.000	71300.000	43300.000	76800.000	25800.000	82100.000	70200.000	56600.000	50700.000
40600.000	61400.000	85000.000	63700.000	51800.000	48800.000	40400.000	78800.000	49400.000	47800.000
25800.000	67000.000	49400.000	27800.000	51600.000	73400.000	73400.000	109000.000	61300.000	78900.000
68800.000	47300.000	69000.000	86000.000	69900.000	95500.000	56400.000	62800.000	75300.000	63500.000
43800.000	49600.000	53100.000	76200.000	69500.000	72600.000	76700.000	66200.000	69500.000	56200.000
68700.000									

MEAN = 64254.098

VARIANCE = **********

STANDARD DEVIATION = 18545.070

SKEWNESS = 0.212

STANDARD ERROR OF SKEWNESS = 0.306

SERIAL CORRELATION COEFFICIENT = -0.063

COEFFICIENT OF VARIATION = 0.289

MEAN LOGS = 4.788

VARIANCE LOGS = 0.019

STANDARD DEVIATION LOGS = 0.136

SKEWNESS LOGS = -0.853

STANDARD ERROR OF SKEWNESS LOGS = 0.306

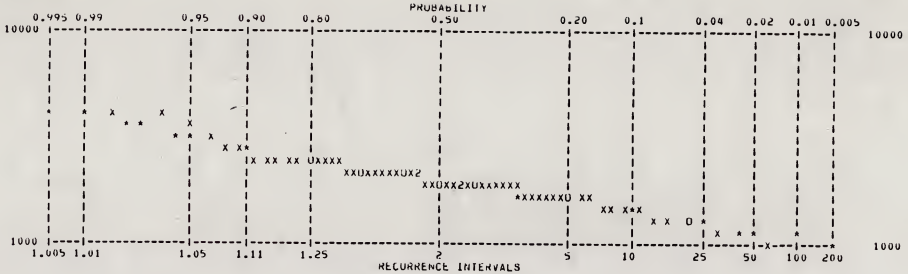
SERIAL CORRELATION COEFFICIENT LOGS = -0.032

COEFFICIENT OF VARIATION LOGS = 0.029

EXCEEDENCE PROB	RECURRENCE INTERVAL	PARAMETER VALUE
0.9900	1.01	24197.895
0.9500	1.05	34080.105
0.9000	1.11	40103.785
0.8000	1.25	47977.945
0.5000	2.00	64179.672
0.2000	5.00	80562.750
0.1000	10.00	88653.625
0.0400	25.00	96625.312
0.0200	50.00	101327.750
0.0100	100.00	105221.000
0.0050	200.00	108489.562

1971-1[illegible] 12 MO. PERIOD ENDING SEPTEMBER 30

1 DAY LOW VALUE



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STATION 12303000

12 MON PERIOD ENDING SEPTEMBER 30

1 DAY LOW VALUE

INPUT DATA (ZERO VALUES OMITTED)

2400.000	2180.000	2040.000	1690.000	2500.000	2600.000	2610.000	1960.000	2160.000	2240.000
2720.000	2100.000	1880.000	2500.000	4000.000	2160.000	3000.000	3500.000	2160.000	1610.000
1990.000	1520.000	1320.000	4140.000	1800.000	1240.000	1230.000	1600.000	1200.000	1700.000
1710.000	2400.000	1400.000	1850.000	1390.000	1980.000	2000.000	2200.000	2000.000	1900.000
2400.000	2500.000	1900.000	1000.000	1700.000	2200.000	1590.000	2120.000	2000.000	2260.000
1920.000	1900.000	1600.000	2500.000	1700.000	2530.000	2650.000	2110.000	2000.000	1650.000
1700.000									

MEAN = 2076.393

VARIANCE = 346935.437

STANDARD DEVIATION = 589.012

SKEWNESS = 1.323

STANDARD ERROR OF SKEWNESS = 0.306

SERIAL CORRELATION COEFFICIENT = 0.170

COEFFICIENT OF VARIATION = 0.284

MEAN LOGS = 3.302

VARIANCE LOGS = 0.014

STANDARD DEVIATION LOGS = 0.117

SKEWNESS LOGS = 0.157

STANDARD ERROR OF SKEWNESS LOGS = 0.306

SERIAL CORRELATION COEFFICIENT LOGS = 0.211

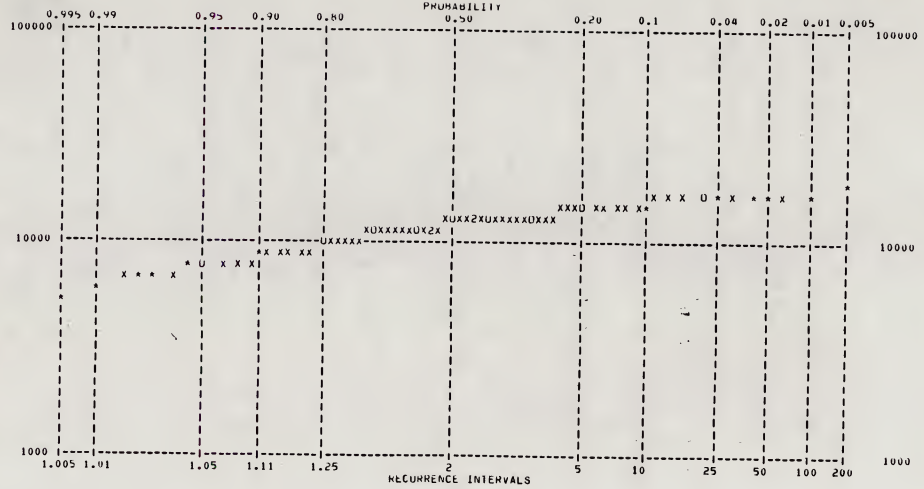
COEFFICIENT OF VARIATION LOGS = 0.035

NON EXCEED PROB	RECURRENCE INTERVAL	PARAMETER VALUE
0.0100	100.00	1105.407
0.0200	50.00	1179.633
0.0500	20.00	1302.663
0.1000	10.00	1425.815
0.2000	5.00	1594.188
0.5000	2.00	1988.528
0.8000	1.25	2505.198
0.9000	1.11	2838.112
0.9600	1.04	3252.022
0.9800	1.02	3557.045
0.9900	1.01	3860.208

STATION 12303000

1911-19 12 MON PERIOD ENDING SEPTEMBER 30

365 DAY HIGH VALUE



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[redacted] ENDING SEPTEMBER 30 STATION 12303000

[redacted]LUE

[redacted] DATA (ZERO VALUES OMITTED)

14000.000	10000.000	13100.000	12600.000	10200.000	16500.000	12000.000	11600.000	12400.000	11100.000
13800.000	10200.000	11900.000	7720.000	13200.000	6510.000	13900.000	14500.000	9360.000	9960.000
7430.000	11900.000	13700.000	15800.000	12000.000	8930.000	8210.000	12400.000	9530.000	8970.000
7650.000	13400.000	12800.000	6870.000	8840.000	13300.000	13200.000	16400.000	10000.000	13700.000
16600.000	13100.000	12000.000	16400.000	12500.000	16000.000	11400.000	10700.000	15500.000	13700.000
14100.000	11300.000	12000.000	12600.000	13600.000	13300.000	14400.000	11700.000	14900.000	9250.000
14400.000									

MEAN = 12115.242

VARIANCE = 6461324.00

STANDARD DEVIATION = 2541.914

SKEWNESS = -0.290

STANDARD ERROR OF SKEWNESS = 0.306

SERIAL CORRELATION COEFFICIENT = 0.036

COEFFICIENT OF VARIATION = 0.210

MEAN LOGS = 4.073

VARIANCE LOGS = 0.010

STANDARD DEVIATION LOGS = 0.099

SKEWNESS LOGS = -0.763

STANDARD ERROR OF SKEWNESS LOGS = 0.306

SERIAL CORRELATION COEFFICIENT LOGS = 0.047

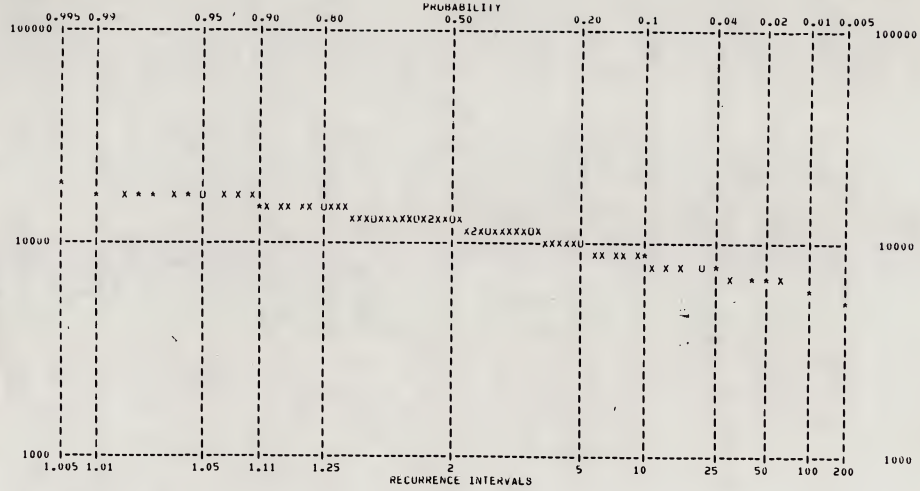
COEFFICIENT OF VARIATION LOGS = 0.024

EXCEEDENCE PROB	RECURRENCE INTERVAL	PARAMETER VALUE
0.9900	1.01	6174.309
0.9500	1.05	7807.539
0.9000	1.11	8738.266
0.8000	1.25	9902.801
0.5000	2.00	12172.062
0.2000	5.00	14365.164
0.1000	10.00	15431.895
0.0400	25.00	16483.645
0.0200	50.00	17108.598
0.0100	100.00	17631.074
0.0050	200.00	18074.984

STATION [illegible]

1911-[illegible] 12 MON PERIOD ENDING SEPTEMBER 30

365 DAY LOW VALUE



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12 MON PERIOD ENDING SEPTEMBER 30

STATION 12303000

365 DAY LOW VALUE

INPUT DATA (ZERO VALUES OMITTED)

14000.000	10000.000	13100.000	12600.000	10200.000	16500.000	12000.000	11600.000	12400.000	11100.000
13800.000	10200.000	11900.000	7720.000	13200.000	6510.000	13900.000	14500.000	9360.000	9960.000
7450.000	11900.000	13700.000	15800.000	12000.000	8930.000	8210.000	12400.000	9530.000	8970.000
7650.000	15400.000	12800.000	6870.000	6840.000	13300.000	13200.000	16400.000	10000.000	13700.000
16600.000	13100.000	12000.000	16400.000	12500.000	16000.000	11400.000	10700.000	15500.000	13700.000
14100.000	11300.000	12000.000	12600.000	13600.000	13300.000	14400.000	11700.000	14900.000	9250.000
14400.000									

MEAN = 12115.242

VARIANCE = 6461324.00

STANDARD DEVIATION = 2541.914

SKEWNESS = -0.290

STANDARD ERROR OF SKEWNESS = 0.306

SERIAL CORRELATION COEFFICIENT = 0.036

COEFFICIENT OF VARIATION = 0.210

MEAN LOGS = 4.073

VARIANCE LOGS = 0.010

STANDARD DEVIATION LOGS = 0.099

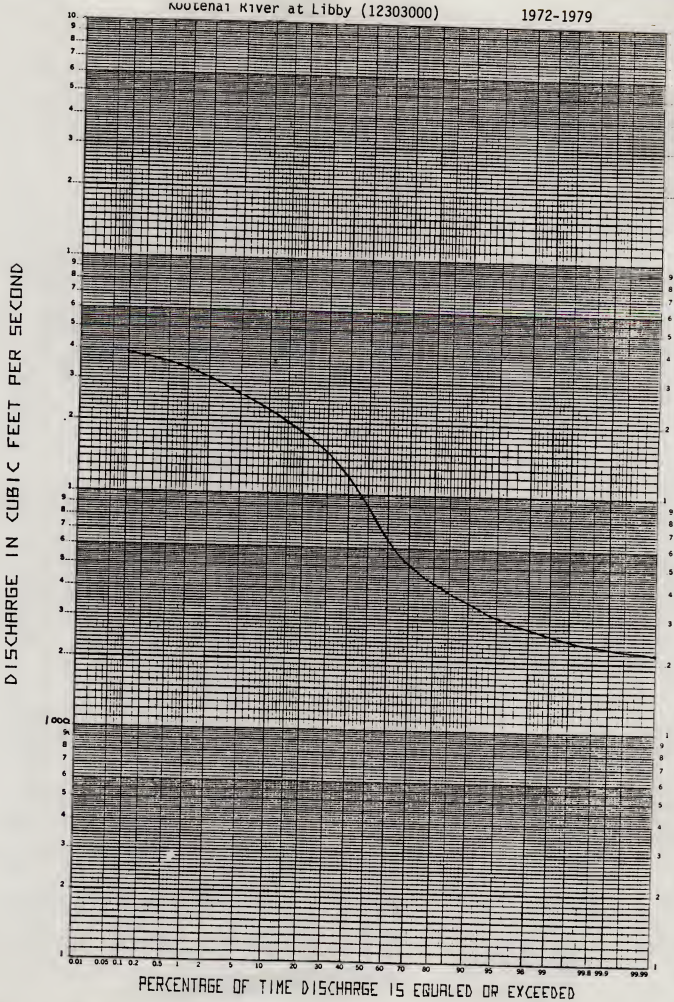
SKEWNESS LOGS = -0.763

STANDARD ERROR OF SKEWNESS LOGS = 0.306

SERIAL CORRELATION COEFFICIENT LOGS = 0.047

COEFFICIENT OF VARIATION LOGS = 0.024

NON EXCEED PROB	RECURRENCE INTERVAL	PARAMETER VALUE
0.0100	100.00	6174.309
0.0200	50.00	6807.309
0.0500	20.00	7607.539
0.1000	10.00	8738.266
0.2000	5.00	9902.801
0.5000	2.00	12172.062
0.8000	1.25	14365.164
0.9000	1.11	15431.895
0.9600	1.04	16483.645
0.9800	1.02	17108.598
0.9900	1.01	17631.074


Kootenai River at Libby (12303000)
1972-1979
DISCHARGE IN CUBIC FEET PER SECOND
PERCENTAGE OF TIME DISCHARGE IS EQUALED OR EXCEEDED
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99

STATION NUMBER 12303000

DURATION TABLE OF DAILY VALUES FOR YEAR ENDING SEPTEMBER 30

DISCHARGE-(CFS)
MEAN
KOOTENAI RIVER AT LIBBY, MT.

CLASS	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
YEAR	NUMBER OF DAYS IN CLASS																																		
1972		6	11	19	14	20	10	14	19	20	26	11	13	8	6	11	6	11	9	5	3	6	3	1	12	3	4	3	4	15	21	25	12	8	
1973		1	8	14	10	53	38	50	18	20	7	5	5	7		4	10	3	3	1		2	1	4	4	22	9	10	4	6	6	22	12	1	
1974				8	19	11	2		1	3	6	6	18	2	5	14	15	7	43	14	6	8	11	29	26	59	17	12	1	7	4	6	1	1	3
1975				8	17	8	4	6	9	10	15	16	15	2	3	10	23	6	14	37	5	4	20	3	24	28	12	2	11	43	10					
1976								1	1	8	15	15	8	15	7	11	8	8	28	18	12	18	17	23	38	37	12	10	15	40		1			
1977						19	24	22	26	13	11	7	4	8	10	11	6	16	19	16	15	33	22	18	22	22	20					1			
1978							2	4	45	17	22	23	29	12	10	9	11	14	24	31	19	22	29	11	4	17	10								
1979						25	5	7	32	36	33	24	20	28	9	9	15	4	5	6	3	1	16	6	8	19	24	30								

CLASS	VALUE	TOTAL	ACCUM	PERCT
0	0.0	0	2922	100.0
1	2200.0	7	2922	100.0
2	2400.0	27	2915	99.8
3	2600.0	63	2888	98.8
4	2900.0	51	2825	96.7
5	3100.0	132	2774	94.9
6	3400.0	87	2642	90.4
7	3700.0	112	2555	87.4
8	4100.0	152	2443	83.6
9	4400.0	132	2291	78.4
10	4800.0	138	2159	73.9
11	5300.0	106	2021	69.2
12	5800.0	99	1915	65.5
13	6500.0	83	1816	62.1
14	6900.0	57	1733	59.3
15	7500.0	92	1676	57.4
16	8200.0	77	1584	54.2
17	8900.0	77	1507	51.6
18	9700.0	168	1430	48.9
19	11000.0	96	1262	43.2
20	12000.0	62	1166	39.9
21	13000.0	110	1104	37.8
22	14000.0	102	994	34.0
23	15000.0	116	892	30.5
24	16000.0	142	776	26.5
25	18000.0	191	634	21.6
26	20000.0	98	443	15.1
27	21000.0	76	345	11.8
28	23000.0	67	269	9.2
29	25000.0	78	202	6.9
30	28000.0	31	124	4.2
31	30000.0	55	93	3.1
32	33000.0	25	38	1.3
33	36000.0	10	13	.4
34	39000.0	3	3	.1

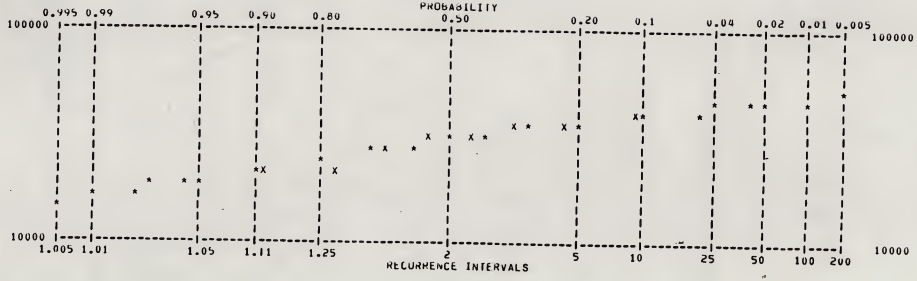
VALUE EXCEEDED "P" PERCENT OF TIME

V95 =	3100.0
V90 =	3400.0
V75 =	4700.0
V70 =	5200.0
V50 =	9800.0
V25 =	17000.0
V10 =	22000.0

KOOTENAI RIVER AT LIBBY, MT. N = 8 STATION 12303000

1978-1979, 12 MON PERIOD ENDING SEPTEMBER 30

1 DAY HIGH VALUE



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[redacted] RIVER AT LIBBY, MT. N = 8 STATION 12303000

1972-1979, 12 MON PERIOD ENDING SEPTEMBER 30

1 DAY HIGH VALUE

INPUT DATA (ZERO VALUES OMITTED)

36400.000 37600.000 39500.000 27100.000 30100.000 31800.000 20900.000 22600.000

MEAN = 30750.000

VARIANCE = 47671392.0

STANDARD DEVIATION = 6904.449

SKEWNESS = -0.216

STANDARD ERROR OF SKEWNESS = 0.752

SERIAL CORRELATION COEFFICIENT = 0.523

COEFFICIENT OF VARIATION = 0.225

MEAN LOGS = 4.478

VARIANCE LOGS = 0.010

STANDARD DEVIATION LOGS = 0.102

SKEWNESS LOGS = -0.475

STANDARD ERROR OF SKEWNESS LOGS = 0.752

SERIAL CORRELATION COEFFICIENT LOGS = 0.523

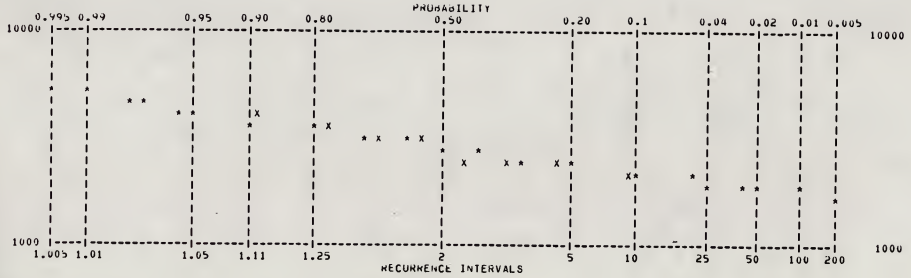
COEFFICIENT OF VARIATION LOGS = 0.023

EXCEEDENCE PROB	RECURRENCE INTERVAL	PARAMETER VALUE
0.9900	1.01	16017.887
0.9500	1.05	19800.512
0.9000	1.11	21998.816
0.8000	1.25	24814.621
0.5000	2.00	30598.660
0.2000	5.00	36749.254
0.1000	10.00	40038.437
0.0400	25.00	43553.383
0.0200	50.00	45809.484
0.0100	100.00	47818.254
0.0050	200.00	49633.148

KOOTENAI RIVER AT LIBBY, MT. N = 8 STATION 12303000

1972-1979, 12 MON PERIOD ENDING SEPTEMBER 30

1 DAY LOW VALUE



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KOOTENAI RIVER AT LIBBY, MT. N = 8 STATION 12303000

1972-1979, 12 MON PERIOD ENDING SEPTEMBER 30

1 DAY LOW VALUE

INPUT DATA (ZERO VALUES OMITTED)

2200.000 2300.000 2600.000 2430.000 3970.000 3200.000 3630.000 3110.000

MEAN = 2930.000

VARIANCE = 423657.125

STANDARD DEVIATION = 650.889

SKEWNESS = 0.479

STANDARD ERROR OF SKEWNESS = 0.752

SERIAL CORRELATION COEFFICIENT = 0.353

COEFFICIENT OF VARIATION = 0.222

MEAN LOGS = 3.456

VARIANCE LOGS = 0.009

STANDARD DEVIATION LOGS = 0.095

SKEWNESS LOGS = 0.258

STANDARD ERROR OF SKEWNESS LOGS = 0.752

SERIAL CORRELATION COEFFICIENT LOGS = 0.437

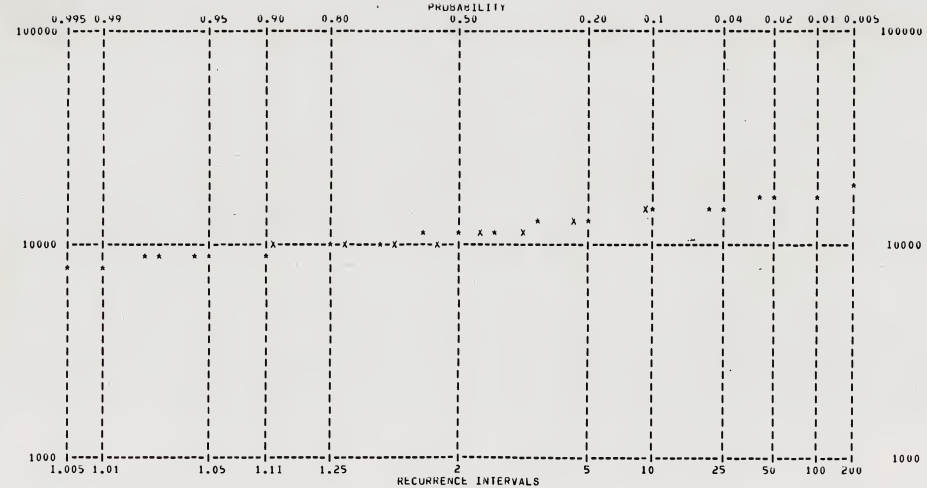
COEFFICIENT OF VARIATION LOGS = 0.028

NON EXCEED PROB	RECURRENCE INTERVAL	PARAMETER VALUE
0.0100	100.00	1796.787
0.0200	50.00	1886.509
0.0500	20.00	2034.499
0.1000	10.00	2181.101
0.2000	5.00	2380.383
0.5000	2.00	2841.755
0.8000	1.25	3437.975
0.9000	1.11	3818.518
0.9600	1.04	4288.711
0.9800	1.02	4633.547
0.9900	1.01	4975.137

MAUMEE RIVER AT LIBBY, MI. n = 8 STATION 12303000

1972-1979, 12 MON PERIOD ENDING SEPTEMBER 30

365 DAY HIGH VALUE



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[redacted]IVER AT LIBBY, MT. N = 0 STATION 12303000

1972-1979, 12 MON PERIOD ENDING SEPTEMBER 30

365 DAY HIGH VALUE

INPUT DATA (ZERO VALUES OMITTED)

12100.000 10000.000 13500.000 11900.000 14600.000 10300.000 9520.000 9510.000

MEAN = 11428.750

VARIANCE = 3665693.00

STANDARD DEVIATION = 1914.600

SKEWNESS = 0.619

STANDARD ERROR OF SKEWNESS = 0.752

SERIAL CORRELATION COEFFICIENT = 0.042

COEFFICIENT OF VARIATION = 0.168

MEAN LOGS = 4.053

VARIANCE LOGS = 0.005

STANDARD DEVIATION LOGS = 0.071

SKEWNESS LOGS = 0.454

STANDARD ERROR OF SKEWNESS LOGS = 0.752.

SERIAL CORRELATION COEFFICIENT LOGS = 0.099

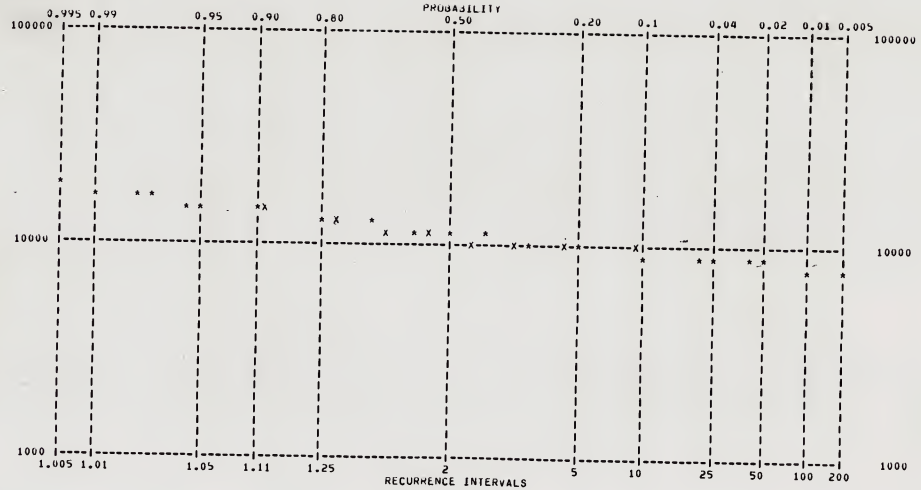
COEFFICIENT OF VARIATION LOGS = 0.018

EXCEEDENCE PROB	RECURRENCE INTERVAL	PARAMETER VALUE
0.9900	1.01	8157.430
0.9500	1.05	8827.875
0.9000	1.11	9245.914
0.8000	1.25	9818.160
0.5000	2.00	11154.934
0.2000	5.00	12897.680
0.1000	10.00	14015.676
0.0400	25.00	15401.488
0.0200	50.00	16420.461
0.0100	100.00	17431.766
0.0050	200.00	18445.039

KOOTENAI RIVER AT LIBBY, MT. N = 8 STATION 12303000

1972-1979, 12 MON PERIOD ENDING SEPTEMBER 30

365 DAY LOW VALUE



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KOOTENAI RIVER AT LIBBY, MT. N = 8 STATION 12303000

1972-1979, 12 MON PERIOD ENDING SEPTEMBER 30

365 DAY LOW VALUE

INPUT DATA (ZERO VALUES OMITTED)

12100.000 10000.000 13500.000 11900.000 14600.000 10300.000 9520.000 9510.000

MEAN = 11428.750

VARIANCE = 3665693.00

STANDARD DEVIATION = 1914.600

SKEWNESS = 0.619

STANDARD ERROR OF SKEWNESS = 0.752

SERIAL CORRELATION COEFFICIENT = 0.042

COEFFICIENT OF VARIATION = 0.168

MEAN LOGS = 4.053

VARIANCE LOGS = 0.005

STANDARD DEVIATION LOGS = 0.071

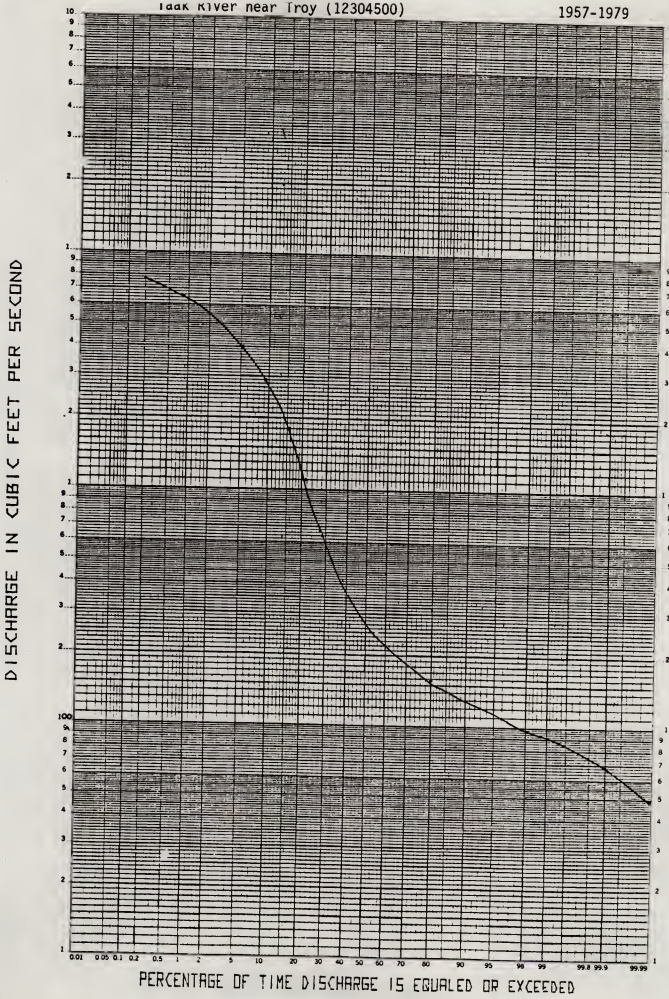
SKEWNESS LOGS = 0.454

STANDARD ERROR OF SKEWNESS LOGS = 0.752

SERIAL CORRELATION COEFFICIENT LOGS = 0.099

COEFFICIENT OF VARIATION LOGS = 0.018

NON EXCEED PROB	RECURRENCE INTERVAL	PARAMETER VALUE
0.0100	100.00	8157.430
0.0200	50.00	8409.207
0.0500	20.00	8827.875
0.1000	10.00	9245.914
0.2000	5.00	9818.160
0.5000	2.00	11154.934
0.8000	1.25	12897.680
0.9000	1.11	14015.676
0.9600	1.04	15401.488
0.9800	1.02	16420.461
0.9900	1.01	17431.766


Teak River near Troy (12304500)
1957-1979
DISCHARGE IN CUBIC FEET PER SECOND
PERCENTAGE OF TIME DISCHARGE IS EQUALED OR EXCEEDED
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99

STATION NUMBER 12304500

DURATION TABLE OF DAILY VALUES FOR YEAR ENDING SEPTEMBER 30

DISCHARGE, IN CUBIC FEET PER SECOND
MEAN
YAAK RIVER NEAR TROY, MT.

CLASS	VALUE	TOTAL	ACCUM	PERCT	CLASS	VALUE	TOTAL	ACCUM	PERCT	CLASS	VALUE	TOTAL	ACCUM	PERCT
0	0.0	9	8400	100.0	12	300.0	445	4078	48.5	24	2100.0	153	1125	13.3
1	50.0	5	8400	100.0	13	350.0	355	3633	43.3	25	2500.0	102	972	11.5
2	59.0	6	8397	100.0	14	410.0	333	3282	39.1	26	2900.0	168	810	9.6
3	69.0	27	8391	99.9	15	490.0	262	2929	34.9	27	3400.0	191	642	7.6
4	81.0	108	8364	99.6	16	570.0	239	2667	31.8	28	4000.0	157	451	5.3
5	96.0	168	8256	98.3	17	670.0	220	2428	28.9	29	4700.0	124	294	3.5
6	110.0	425	8088	96.0	18	790.0	218	2208	26.3	30	5500.0	87	170	2.0
7	130.0	914	7663	91.0	19	930.0	165	1990	23.7	31	6500.0	58	83	.9
8	160.0	649	6729	80.1	20	1100.0	175	1825	21.7	32	7700.0	22	25	.2
9	180.0	914	6060	72.4	21	1300.0	173	1650	19.6	33	9000.0	3	3	
10	220.0	456	5166	61.5	22	1500.0	189	1477	17.6	34	11000.0			
11	250.0	632	4710	56.1	23	1800.0	163	1288	15.3					

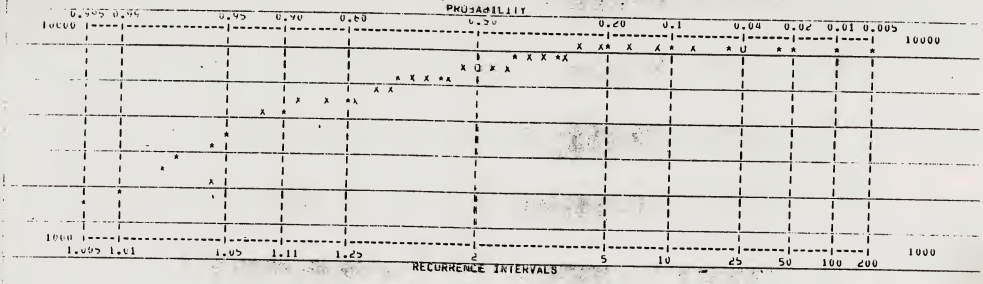
VALUE EXCEEDED "P" PERCENT OF TIME

V95 =	110.0
V90 =	130.0
V75 =	170.0
V70 =	190.0
V50 =	290.0
V25 =	860.0
V10 =	2800.0

STATION 12304500

1957-1976, 12 MO. PERIOD ENDING SEPTEMBER 30

1 EXPLANATION VALUE



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STATION 12304500

12 MON PERIOD ENDING SEPTEMBER 30

1 DAY HIGH VALUE

INPUT DATA (ZERO VALUES OMITTED)

7470.000	5720.000	8240.000	7230.000	8850.000	4800.000	4260.000	7440.000	6400.000	6960.000
9330.000	4900.000	7620.000	5240.000	8890.000	8300.000	5140.000	8270.000	6700.000	9210.000
1820.000	5650.000	4380.000							

MEAN = 6560.434

VARIANCE = 3569947.00

STANDARD DEVIATION = 1889.444

SKEWNESS = -0.498

STANDARD ERROR OF SKEWNESS = 0.481

SERIAL CORRELATION COEFFICIENT = -0.232

COEFFICIENT OF VARIATION = 0.286

MEAN LOGS = 3.794

VARIANCE LOGS = 0.025

STANDARD DEVIATION LOGS = 0.157

SKEWNESS LOGS = -1.817

STANDARD ERROR OF SKEWNESS LOGS = 0.481

SERIAL CORRELATION COEFFICIENT LOGS = -0.177

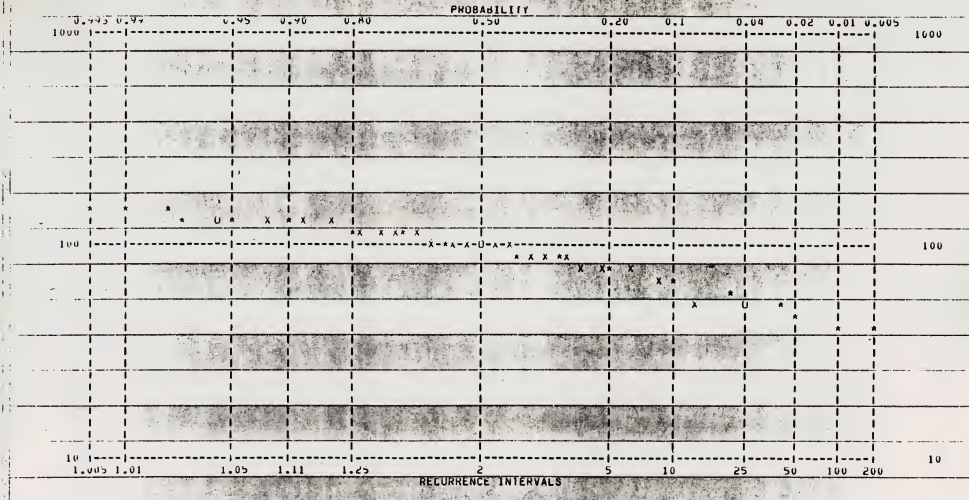
COEFFICIENT OF VARIATION LOGS = 0.041

EXCEEDENCE PROB	RECURRENCE INTERVAL	PARAMETER VALUE
0.9900	1.01	1754.592
0.9500	1.05	3043.970
0.9000	1.11	3871.652
0.8000	1.25	4941.699
0.5000	2.00	6899.031
0.2000	5.00	8803.293
0.1000	10.00	8745.711
0.0400	25.00	9028.464
0.0200	50.00	9133.535
0.0100	100.00	9192.012
0.0050	200.00	9224.785

YEAR [illegible] DAY FLOW, CFS. N = STATION 12304500

1975-1976, 12 MON PERIOD ENDING SEPTEMBER 30

1 DAY LOW VALUE



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STATION 12304500

12 -DAY PERIOD ENDING SEPTEMBER 30

1 DAT LOG VALUE

INPUT DATA (ZERO VALUES OMITTED)

60.000	69.000	118.000	125.000	115.000	90.000	126.000	116.000	100.000	98.000
90.000	80.000	129.000	95.000	95.000	100.000	50.000	96.000	117.000	125.000
55.000	90.000	65.000							

MEAN = 97.174

VARIANCE = 499.676

STANDARD DEVIATION = 22.358

SKEWNESS = -0.450

STANDARD ERROR OF SKEWNESS = 0.481

SERIAL CORRELATION COEFFICIENT = 0.055

COEFFICIENT OF VARIATION = 0.230

MEAN LOGS = 1.975

VARIANCE LOGS = 0.012

STANDARD DEVIATION LOGS = 0.111

SKEWNESS LOGS = -1.011

STANDARD ERROR OF SKEWNESS LOGS = 0.481

SERIAL CORRELATION COEFFICIENT LOGS = 0.016

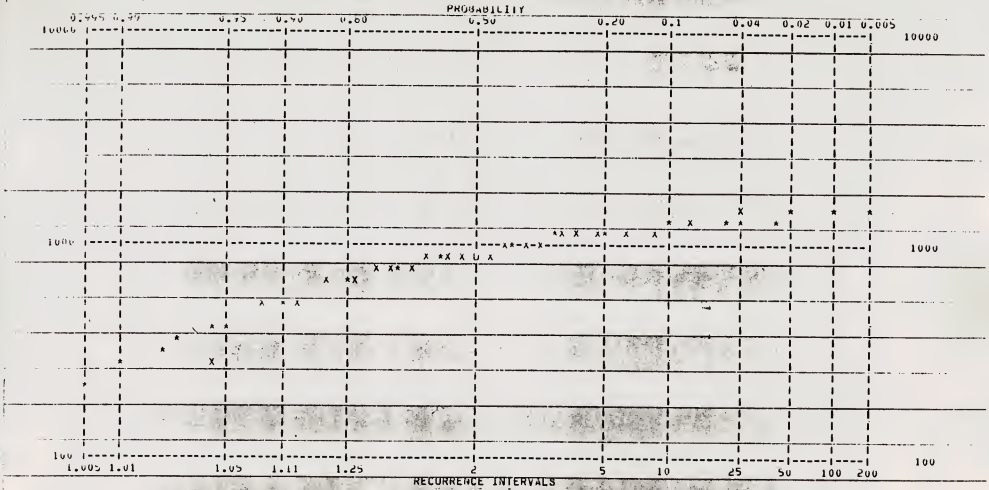
COEFFICIENT OF VARIATION LOGS = 0.056

NON EXCEED PROB	RECURRENCE INTERVAL	PARAMETER VALUE
0.0100	100.00	43.385
0.0200	50.00	49.106
0.0500	20.00	58.288
0.1000	10.00	66.920
0.2000	5.00	77.742
0.5000	2.00	98.487
0.8000	1.25	117.426
0.9000	1.11	125.983
0.9600	1.04	133.843
0.9800	1.02	138.185
0.9900	1.01	141.593

STATION 12304500

...-... OF RECORD ENDING SEPTEMBER 30

365 DAY MEAN VALUE



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[illegible], 12 MO PERIOD ENDING SEPTEMBER 30 STATION 12304500

365 DAY HIGH VALUE

INPUT DATA (ZERO VALUES OMITTED)

731.000	649.000	1170.000	1210.000	1050.000	745.000	845.000	842.000	976.000	897.000
449.000	782.000	1240.000	671.000	1080.000	1130.000	518.000	1560.000	856.000	1040.000
278.000	848.000	497.000							

MEAN = 897.045

VARIANCE = 79038.500

STANDARD DEVIATION = 281.241

SKEWNESS = 0.058

STANDARD ERROR OF SKEWNESS = 0.481

SERIAL CORRELATION COEFFICIENT = -0.269

COEFFICIENT OF VARIATION = 0.314

MEAN LOGS = 2.928

VARIANCE LOGS = 0.025

STANDARD DEVIATION LOGS = 0.159

SKEWNESS LOGS = -1.203

STANDARD ERROR OF SKEWNESS LOGS = 0.481

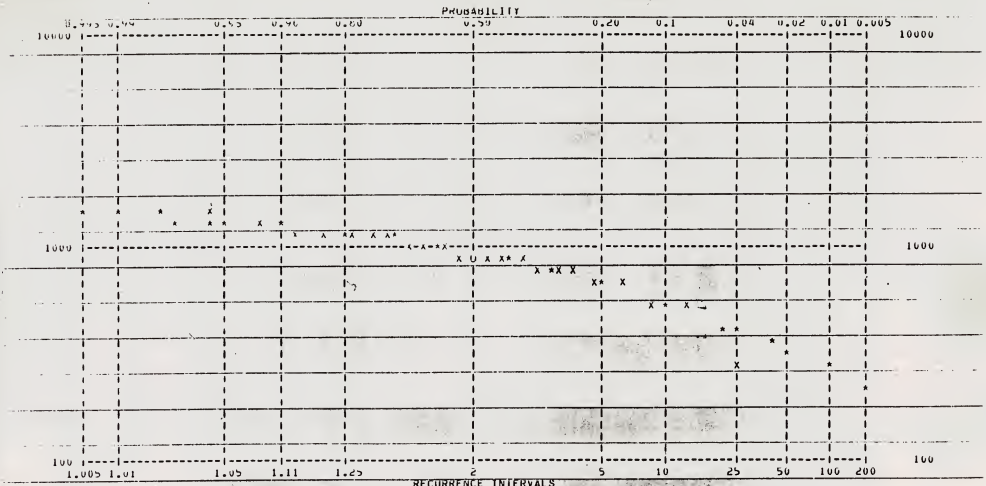
SERIAL CORRELATION COEFFICIENT LOGS = -0.230

COEFFICIENT OF VARIATION LOGS = 0.054

EXCEEDENCE PROB	RECURRENCE INTERVAL	PARAMETER VALUE
0.9900	1.01	263.086
0.9500	1.05	419.599
0.9000	1.11	519.674
0.8000	1.25	651.421
0.5000	2.00	915.038
0.2000	5.00	1152.697
0.1000	10.00	1253.146
0.0400	25.00	1336.145
0.0200	50.00	1380.910
0.0100	100.00	1411.766
0.0050	200.00	1434.561

STATION 12304500

365 DAY LOW VALUE



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STATION 12304500

12 MON PERIOD ENDING SEPTEMBER 30

365 DAY LOW VALUE

INPUT DATA (ZERO VALUES OMITTED)

751.000	699.000	1170.000	1210.000	1090.000	745.000	843.000	842.000	976.000	897.000
949.000	766.000	1240.000	871.000	1080.000	1130.000	518.000	1560.000	856.000	1040.000
276.000	848.000	497.000							

MEAN = 897.043

VARIANCE = 79096.500

STANDARD DEVIATION = 281.241

SKEWNESS = 0.058

STANDARD ERROR OF SKEWNESS = 0.481

SERIAL CORRELATION COEFFICIENT = -0.269

COEFFICIENT OF VARIATION = 0.314

MEAN LOGS = 2.928

VARIANCE LOGS = 0.025

STANDARD DEVIATION LOGS = 0.159

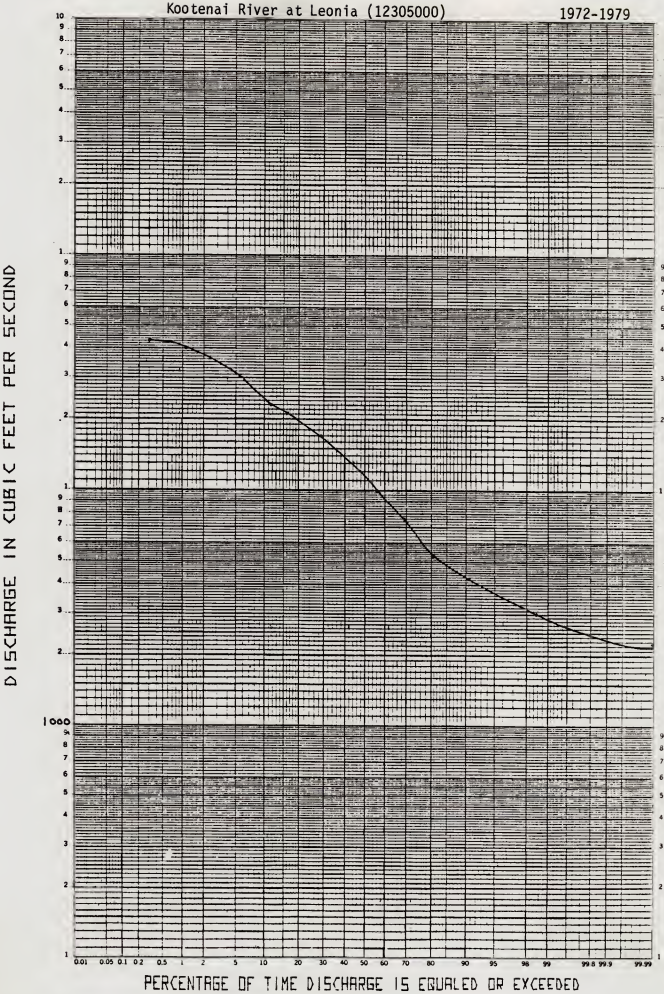
SKEWNESS LOGS = -1.283

STANDARD ERROR OF SKEWNESS LOGS = 0.481

SERIAL CORRELATION COEFFICIENT LOGS = -0.230

COEFFICIENT OF VARIATION LOGS = 0.054

NON EXCEED PROB	RECURRENCE INTERVAL	PARAMETER VALUE
0.0100	100.00	265.083
0.0200	50.00	320.626
0.0500	20.00	419.899
0.1000	10.00	519.674
0.2000	5.00	651.421
0.5000	2.00	915.038
0.8000	1.25	1152.697
0.9000	1.11	1253.146
0.9600	1.04	1338.145
0.9800	1.02	1380.910
0.9900	1.01	1411.786


Kootenai River at Leonia (12305000)
1972-1979
DISCHARGE IN CUBIC FEET PER SECOND
1000
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
PERCENTAGE OF TIME DISCHARGE IS EQUALED OR EXCEEDED

STATION NUMBER 12305000

DURATION TABLE OF DAILY VALUES FOR YEAR ENDING SEPTEMBER 30

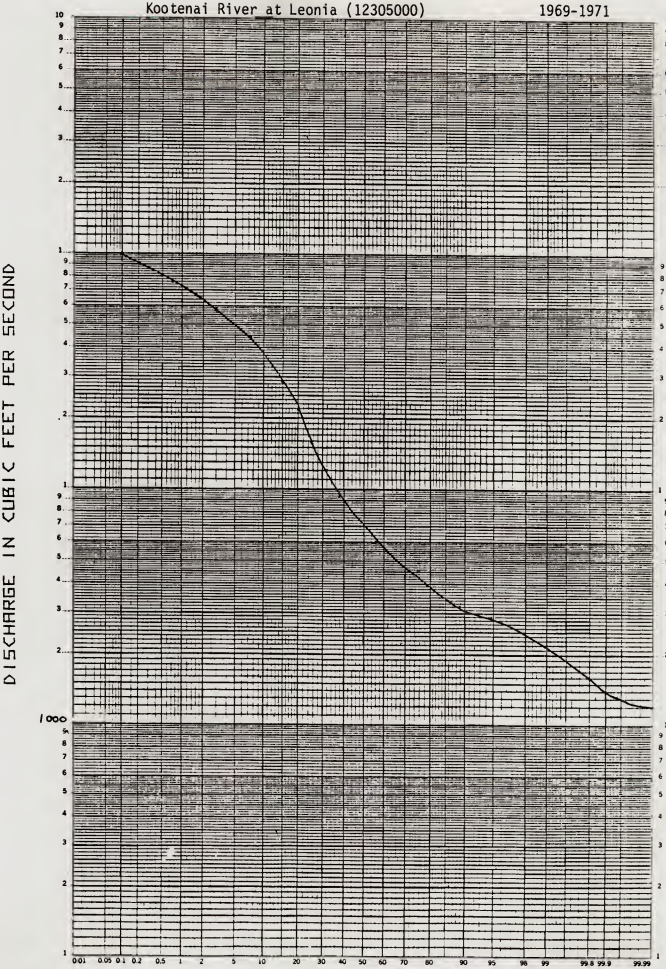
DISCHARGE, IN CUBIC FEET PER SECOND
MEAN
KOOTENAI RIVER AT LEONIA IDAHO

CLASS																																
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
													NUMBER OF DAYS IN CLASS																				
1972			3	8	10	16	22	9	7	28	20	23	17	2	5	2	19	13	11	6	10	16	5	3	7	8	9	4	6	6	23	9	15	20	4
1973			4	6	9	7	25	27	5	53	23	14	15	16	14	10	15	3	9	2	3	6	3		3	33	9	4	7	9	19	11	1		
1974					1	4	12	7	9	4	3	1	13	7	4	11	11	19	40	20	17	11	13	11	45	28	6	5	14	11	15	13	5	4	1
1975					5	15	13	4	8	2	12	8	11	6	7	16	9	13	33	5	29	9	41	22	17	14	47	19							
1976										1				3	7	15	25	14	29	15	39	15	24	46	37	29	9	13	42	1	1		1	
1977							20	7	23	16	20	17	14	9	12	12	22	10	20	17	46	21	17	27	30	4			1					
1978									3	22	15	9	6	18	27	16	29	26	35	28	52	28	6	17	23	5								
1979							14	7	36	8	5	32	27	37	11	21	11	13	14	10	23	6	2	17	38	33								

CLASS	VALUE	TOTAL	ACCUM	PERCT
0	0.0	0	2922	100.0
1	2270.0	7	2922	100.0
2	2500.0	14	2915	99.8
3	2700.0	19	2901	99.3
4	3000.0	29	2882	98.6
5	3300.0	66	2853	97.6
6	3600.0	95	2787	95.4
7	4000.0	37	2692	92.1
8	4300.0	160	2655	90.9
9	4800.0	96	2495	85.4
10	5200.0	92	2399	82.1
11	5700.0	99	2307	79.0
12	6300.0	89	2208	75.6
13	6900.0	99	2119	72.5
14	7600.0	80	2020	69.1
15	8300.0	125	1940	66.4
16	9100.0	123	1815	62.1
17	10000.0	115	1692	57.9
18	11000.0	179	1577	54.0
19	12000.0	108	1398	47.8
20	13000.0	228	1290	44.1
21	15000.0	98	1062	36.3
22	16000.0	106	964	33.0
23	17000.0	150	858	29.4
24	19000.0	231	708	24.2
25	21000.0	131	477	16.3
26	23000.0	70	346	11.8
27	25000.0	50	276	9.4
28	28000.0	72	226	7.7
29	30000.0	54	154	5.2
30	33000.0	36	100	3.4
31	37000.0	29	64	2.1
32	40000.0	26	35	1.1
33	44000.0	8	9	.3
34	49000.0	1	1	

VALUE EXCEEDED 'P' PERCENT OF TIME

V95 = 3600.0
V90 = 4400.0
V75 = 6400.0
V70 = 7400.0
V50 = 12000.0
V25 = 19000.0
V10 = 25000.0


Kootenai River at Leonia (12305000)
1969-1971
DISCHARGE IN CUBIC FEET PER SECOND
1000
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
PERCENTAGE OF TIME DISCHARGE IS EQUALED OR EXCEEDED

STATION NUMBER 12305000

OURATION TABLE OF DAILY VALUES FOR YEAR ENDING SEPTEMBER 30

DISCHARGE, IN CUBIC FEET PER SECOND
MEAN
KOOTENAI RIVER AT LEONIA IDAHO

CLASS																														
YEAR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
													NUMBER OF DAYS IN CLASS																					
1969									4	11	47	13	21	40	38	45	14	4	8	8	8	7	9	8	10	9	8	15	19	10	9				
1970				2	7	8	8	12	50	36	18	44	50	23	10	14	6	5	4	7	8	6	8	5	10	12	6	4	2						
1971							7	16	18	11	39	31	34	23	12	13	24	7	14	7	8	5	2	13	16	10	8	8	12	13	11	3			

CLASS	VALUE	TOTAL	ACCUM	PERCT
0	0.0	2	15705	100.0
1	1070.0	1	15703	100.0
2	1200.0	14	15702	100.0
3	1400.0	14	15688	99.9
4	1600.0	40	15674	99.8
5	1900.0	98	15634	99.5
6	2200.0	195	15536	98.9
7	2500.0	553	15341	97.7
8	2900.0	889	14788	94.2
9	3400.0	996	13899	88.5
10	3900.0	1215	12903	82.2
11	4500.0	1425	11688	74.4
12	5200.0	1419	10263	65.3
13	6000.0	1187	8844	56.3
14	6900.0	865	7657	48.8
15	7900.0	775	6792	43.2
16	9100.0	822	6017	38.3
17	11000.0	286	5195	33.1
18	12000.0	521	4909	31.3
19	14000.0	397	4388	27.9
20	16000.0	467	3991	25.4
21	19000.0	381	3524	22.4
22	22000.0	344	3143	20.0
23	25000.0	434	2799	17.8
24	29000.0	419	2365	15.0
25	33000.0	415	1946	12.3
26	38000.0	352	1531	9.7
27	44000.0	410	1179	7.5
28	51000.0	300	769	4.8
29	59000.0	208	469	2.9
30	68000.0	150	261	1.6
31	78000.0	64	111	.7
32	90000.0	29	47	.2
33	100000.0	16	18	.1
34	120000.0	2	2	

VALUE EXCEEDED 'P' PERCENT OF TIME

V95 = 2800.0
V90 = 3300.0
V75 = 4500.0
V70 = 4800.0
V50 = 6800.0
V25 = 16000.0
V10 = 38000.0

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

RUN-DATE 10/11/80 AT 19 SE .0001

OPTIONS IN EFFECT -- PLOT NOBC LGPT NOOA PPOS NORS EXPR CL1M

STATION - 12305000/PK KOOTENAI RIVER AT LEONIA,ID. 12305000/PK

INPUT DATA SUMMARY

-- YEARS OF RECORD -- SYSTEMATIC	HISTORIC	HISTORIC PEAKS	GENERALIZED SKEW	SKEW OPTION	GAGE BASE DISCHARGE	USER-SET OUTLIER CRITERIA HIGH OUTLIER	LOW OUTLIER
8	0	0	-0.300	GENERALIZED	0.0	--	--

********* NOTICE -- PRELIMINARY MACHINE COMPUTATIONS. *********
********* USER RESPONSIBLE FOR ASSESSMENT AND INTERPRETATION. *********

**WCF134-SYSTEMATIC RECORD SHORTER THAN WRC SPEC. 8
WCF134-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE. 0.0
WCF195-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION. 14488.2
WCF163-NO HIGH OUTLIERS OR HISTORIC PEAKS WERE NOTED.
*WCF151-WRC WEIGHTED SKEW REPLACED BY USER OPTION. -0.300 -0.300 1
**WCF233-EXPECTED PROB OUT OF RANGE AT TAR PROB. 0.00000 0.00200
WCF002J-CALCS COMPLETED. RETURN CODE = 2

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	FLOOD BASE DISCHARGE	FLOOD BASE EXCEEDANCE PROBABILITY	LOGARITHMIC MEAN	LOGARITHMIC STANDARD DEVIATION	LOGARITHMIC SKEW
SYSTEMATIC RECORD	0.0	1.0000	4.5823	0.1578	-0.307
W R C ESTIMATE	0.0	1.0000	4.5823	0.1578	-0.300

ANNUAL FREQUENCY CURVE ORDINATES -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

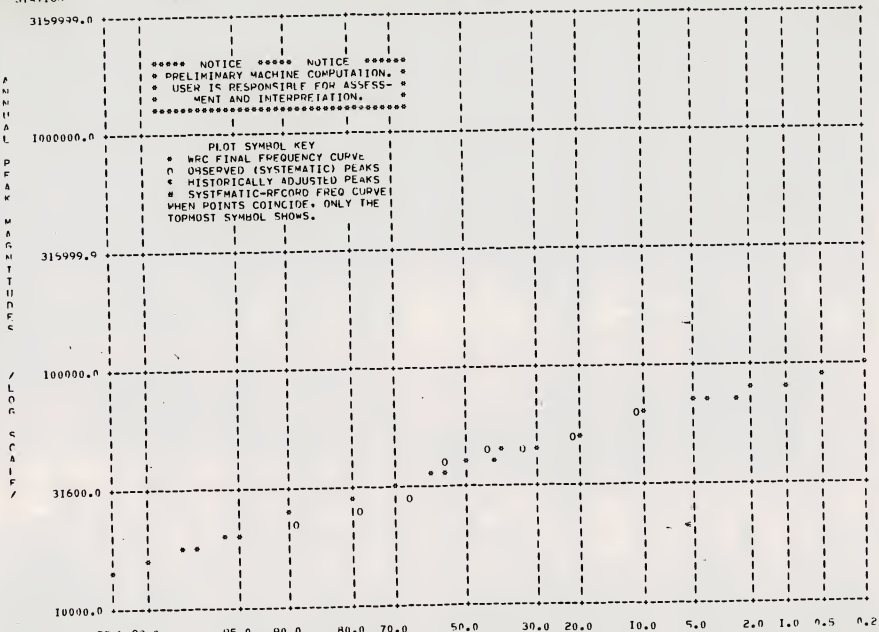
ANNUAL EXCEEDANCE PROBABILITY	W R C ESTIMATE	SYSTEMATIC RECORD	*EXPECTED-PROBABILITY* ESTIMATE	95-PCT CONFIDENCE LIMITS FOR W R C ESTIMATES LOWER	UPPER
0.9950	13538.4	13507.8	7810.6	5720.8	19481.8
0.9900	15164.4	15137.9	10099.2	6967.8	21189.5
0.9500	20417.0	20404.4	17430.8	11601.8	26603.2
0.9000	23750.7	23764.2	21473.5	14930.8	30076.9
0.8000	28333.5	28338.4	26920.7	19805.8	35115.6
0.5000	38919.4	38935.2	38919.4	30886.6	49469.5
0.2000	52103.0	52106.3	54301.1	42006.9	74974.1
0.1000	60085.0	60065.3	64770.4	47623.9	94164.9
0.0400	69436.8	69374.0	78967.3	53619.3	119716.4
0.0200	75937.2	75834.1	90867.4	57534.9	139284.7
0.0100	82087.7	81938.7	103554.0	61097.3	159100.7
0.0050	87964.1	87763.8	117648.1	64394.4	179181.8
0.0020	95394.1	95118.6	**********	68437.9	206138.4

PRIM JO[illegible]H 3.4
(REV I[illegible]22/79)

U. S. GEOLOGICAL [illegible]EY
ANNUAL PEAK FLOW FREQU[illegible] ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

RUN-DATE 10/11/80 AT 19 SE[illegible] .0001

STATION - 12305000/PK KOOTENAI RIVER AT LEONIA,ID.



U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

RUN-DATE 10/11/80 AT 19 SEQ 1.0001

OPTIONS IN EFFECT -- PLOT NORC LGPT NODB PPOS NORS EXPP CLIM

STATION - 12305000/USGS KOOTENAI RIVER AT LEONIA IDAHO 1928-1979 12305000/USGS

INPUT DATA SUMMARY

-- YEARS OF RECORD -- SYSTEMATIC	HISTORIC	HISTORIC PEAKS	GENERALIZED SKEW	SKEW OPTION	GAGE BASE DISCHARGE	USER-SET OUTLIER CRITERIA HIGH OUTLIER	LOW OUTLIER
52	0	0	-0.300	GENERALIZED	0.0	--	--

********* NOTICE -- PRELIMINARY MACHINE COMPUTATIONS. *********
********* USER RESPONSIBLE FOR ASSESSMENT AND INTERPRETATION. *********

**WCF109W-PEAKS WITH MISSING-DISCHARGE CODES WERE BYPASSED. 8
**WCF113W-NUMBER OF SYSTEMATIC PEAKS HAS BEEN REDUCED TO NSYS = 44
WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE. 0.0
WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION. 24321.4
WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS WERE NOTED.
*WCF151I-WRC WEIGHTED SKEW REPLACED BY USER OPTION. -0.428 -0.300 1
WCF002J-CALCS COMPLETED. RETURN CODE = 2

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	FLOOD BASE DISCHARGE	FLOOD BASE EXCEEDANCE PROBABILITY	LOGARITHMIC MEAN	LOGARITHMIC STANDARD DEVIATION	LOGARITHMIC SKEW
SYSTEMATIC RECORD	0.0	1.0000	4.8429	0.1247	-0.804
W R C ESTIMATE	0.0	1.0000	4.8429	0.1247	-0.300

ANNUAL FREQUENCY CURVE ORDINATES -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

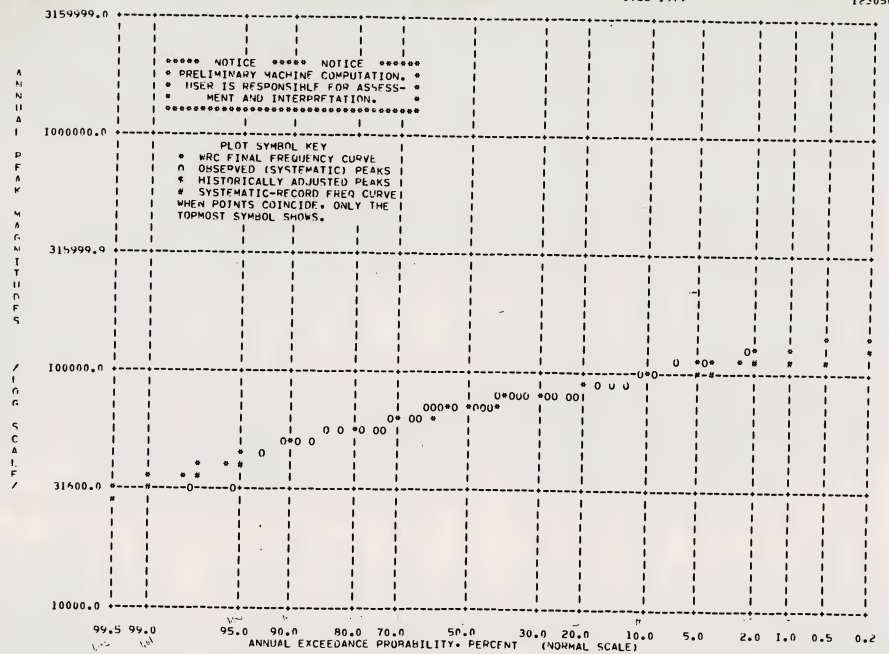
ANNUAL EXCEEDANCE PROBABILITY	W R C ESTIMATE	SYSTEMATIC RECORD	*EXPECTED-PROBABILITY* ESTIMATE	95-PCT CONFIDENCE LIMITS FOR W R C ESTIMATES LOWER	UPPER
0.9950	30674.3	26881.5	28700.1	25281.5	35286.1
0.9900	33549.8	30346.4	31943.2	28140.5	38144.6
0.9500	42436.8	41066.2	41616.4	37183.8	48897.5
0.9000	47823.0	47451.6	47143.4	42752.3	52704.1
0.8000	54976.3	55680.6	54596.9	50143.8	59355.0
0.5000	70647.7	72345.6	70647.7	65744.5	75987.1
0.2000	88960.4	89041.1	89459.3	82354.1	97637.6
0.1000	99564.6	97299.2	100631.3	91363.0	111051.5
0.0400	111619.2	105486.5	113512.3	101263.5	126863.9
0.0200	119796.7	110356.5	122714.6	107825.7	137872.1
0.0100	127399.6	114421.2	131268.1	113837.4	148285.1
0.0050	134552.2	117863.5	139809.6	119424.9	158224.5
0.0020	143454.6	121668.0	149529.3	126298.7	170775.1

PGM J407 VER 3.4
(REV 10/22/79)

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-A.

RUN-DATE 10/11/80 AT 19 SEQ 1.0001

STATION - 12305000/USGS KOOTENAI RIVER AT LEONIA IDAHO 1928-1979 12305000/USGS



APPENDIX B.

Well Logs

Form No 1 GW 2 Revised 1969
STATE PUBLISHING COMPANY

County Liberty

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
MONTANA WATER RESOURCES BOARD

NOTICE OF COMPLETION OF GROUNDWATER APPROPRIATION BY MEANS OF WELL

Developed after January 1, 1962

(Under Chapter 227 Montana Session Laws, 1961, as amended)

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder in the county in which the well is located, last copy to be retained by driller.

Please answer all questions. If not applicable, so state, otherwise the form may be returned.

Owner Vaughn Evans

Address

Kremlin, Montana

Date well started August 3, 1972

completed August 4, 1972

For Administrator's Use
File 927
Feb. 14, 1973.
GW 1 11 50 A-127

Type of well Drilled (Dug, driven, bored or drilled)

Equipment used Air rotary (Cherry drill, rotary or other)

Water Use: Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☐

Industrial ☐ Drainage ☐ Other ☐* Garden/Lawn ☐

*Describe

USE: If used for irrigation, industrial, drainage or other. Explain, state number of acres and location or other data (i.e. Lot, Block and Addition).

ESTIMATED ANNUAL WITHDRAWAL 75,000 Gal. pr. yr.

Size of Bored Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS		
				Bored Hole	From (Feet)	To (Feet)
6"I.D.	6 5/8" O.D. 17.00 lbs. per ft.	0	41		None	

N / W / E / S

Static water level 18 ft.*
Pumping water level ft.*
at 40-50 gallons per minute, measured 120 minutes after pumping began.
*Measured from ground level.
Well developed by air compressor for 2 hours.
Power Pump HP
Remarks: (Gravel packing, cementing, packers, type of shutoff)

Refer to Gas Lease
SW¼ SE¼ Sec. 23
T. 32 N R. 29 E
S W

INDICATE LOCATION OF WELL AND PLACE OF USE, IF POSSIBLE. EACH SMALL SQUARE REPRESENTS 40 ACRES.

Driller's Signature W. W. Foster

Driller's Address P. O. Box 967

DRILLER'S LOG

Indicate the character, color, thickness of strata such as soil, clay, sand, gravel, shale, sandstone, etc. Show depth at which water is found and height to which water rises in well.

Top of Ground (Elev. above sea level)

From (Feet)	To (Feet)	
0	1	Topsoil.
1	22	Sand, Gravel, and Boulders.
22	41	Gravel and Water.

(6)

GW 2 STATE WATER CONSERVATION BOARD Approved Stock Form—State Publishing Co., Helena, Montana—46477

File No. NOV 15 1965

DUPLICATE Book Page Card Date Application Dismissed Dicked

T 32 N R 31 W M.P.M.

County Lincoln

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
OFFICE OF STATE ENGINEER

Top of Ground

(Elev. above sea level.....)

Notice of Completion of Groundwater Appropriation by Means of Well

(Under Chapter 237, Montana Session Laws, 1961)

0'-1' Topsoil.
1'-18' Sandy Clay.
18'-39' Tight Cloy and Gravel.
39'-43' Clay and Gravel.
43'-53' Sand, Gravel and Water.

Owner C. B. Hand Address Troy, Mont.

Driller Wm. D. Lake Address Libby, Mont.

Date of Notice of Appropriation of Groundwater.....

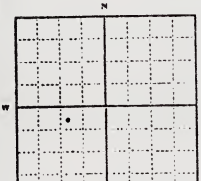
Date well started Oct 25 1965 Date Completed Oct. 28, 1965

Type of well drilled (dug, driven, bored or drilled) Equipment Used churn (Churn, drill, rotary or other)

Water Use: Domestic ☒ Municipal ☐ Other ☐ Irrigation ☐
Industrial ☐ Drainage ☐ Stock ☐

Indicate on the diagram the character and thickness of the different strata met with in drilling, such as soil, clay, shale, gravel, rock or sand, etc. Show depth at which water is encountered, thickness and character of water-bearing strata and height to which water rises in the well.

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS		
				Kind Size	From (Feet)	To (Feet)
6" I.D.	18.97 lbs per foot	0'	53'	none		



SW¼ Sec. 22 T 32 N R 31 W M.P.M.

Indicate location of well and place of use, if possible. Each small square represents 10 acres.

Show exact depth of bottom.

Static Water Level for non-flowing Well 40 feet.

Shut-in Pressure for Flowing Well.....

Pumping Water Level 42 feet at 15 gal. per minute.

Discharge in gal. per min. of flowing well.....

How Tested bailer Length of Test 3 hrs.

Remarks: (Gravel packing, cementing, packers, type of shutoff, location of place of use of groundwater if not at well, and any other similar pertinent information, including number of acres irrigated, if used for irrigation) ½ Acre

Garden & Lawn

152
Driller's License Number

Wm. D. Lake
Driller's Signature

(3)

GW 2

STATE WATER CONSERVATION BOARD

Approved Stock Form—State Publishing Co., Helena, Montana

File No.

NOV 15 1965

T 32 N R 34 W

DUPLICATE

Silv... McDermott
Bu... Mc...
Co... Marion
Dartmon... Sullivan

County Lincoln

Top of Casing

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
OFFICE OF STATE ENGINEER

(Elev. above sea level.....)

Notice of Completion of Groundwater Appropriation by Means of Well

(Under Chapter 237, Montana Session Laws, 1961)

0'-1' Topsoil
1'-12' Clay
12'-17' Loose clay and gravel.
17'-23' Tight clay and gravel.
23'-40' Loose clay and gravel.
40'-53' Sand, gravel and water.

Owner Mrs. A. V. Birrer Address Troy, Mont.

Driller Wm. D. Lake Address Libby, Mont.

Date of Notice of Appropriation of Groundwater.....

Date well started Oct. 29, 1965 Date Completed Nov. 3, 1965

Type of well drilled (dug, driven, bored or drilled) Equipment Used churn (Churn, drill, rotary or other)

Water Use: Domestic ☒ Municipal ☐ Other ☐ Irrigation ☐
Industrial ☐ Drainage ☐ Stock ☐

☜ Indicate on the diagram the character and thickness of the different strata met with in drilling, such as soil, clay, shale, gravel, rock or sand, etc. Show depth at which water is encountered, thickness and character of water-bearing strata and height to which water rises in the well.

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS: Kind Size	From (Feet)	To (Feet)
6" I.D.	18.97 Lbs. per foot	0'	53'	none		

N
W E
S

Lot 14 Plat # 286
SW¼ Sec. 22 T. 32 N. R. 34 W.
Indicate location of well and place of use, if possible. Each small square represents 10 acres.

Show exact depth of bottom.

Static Water Level for non-flowing Well 35 feet.

Shut-in Pressure for Flowing Well.....

Pumping Water Level 36 feet at 20 gal. per minute.

Discharge in gal. per min. of flowing well.....

How Tested bailer Length of Test 2 hrs.

Remarks: (Gravel packing, cementing, packers, type of shutoff, location of place of use of groundwater if not at well, and any other similar pertinent information, including number of acres irrigated, if used for irrigation).....

152
Driller's License Number

Wm D Lake

(4)

Approved Stock Form—Shaw Publishing Co., Helena, Montana—G1[illegible]

ow 1

WATER CONSERVATION BOARD

File No.....

SEP 14 1966

T. 32 R. 34

DUPLICATE

County Lincoln

STATE OF MONTANA

LOG

ADMINISTRATOR OF GROUNDWATER CODE

OFFICE OF STATE ENGINEER

Top of Ground

(Elev. above sea level.....)

Notice of Completion of Groundwater Appropriation by Means of Well

DEVELOPED AFTER JANUARY 1, 1962

(Under Chapter 237, Montana Session Laws, 1961)

Owner Fred Edstrom Address Troy, Mont.

Driller William A. Lake Address Libby, Mont.

Date of Notice of appropriation of groundwater.....

Date well started Aug. 31, 1966 Date completed Sept. 1, 1966

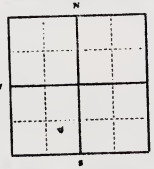
Type of well drilled (Dug, Driven, bored or drilled) Equipment used Churn (Churn drill, rotary or other)

Water use: Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☐ Industrial ☐ Drainage ☐ Other ☐

Indicate on the diagram the character and thickness of the different strata met with in drilling, such as soil, clay, shale, gravel, rock or sand, etc. Show depth at which water is encountered, thickness and character of water-bearing strata and height to which the water rises in the well.

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS: Kind Size	PERFORATIONS: Depth (Feet)	PERFORATIONS: To (Feet)
6" I.D.	18.97 lbs. per foot 6⅝" O.D.	0'	43'	none		

0'-1' Topsoil.
1'-18' Loose clay and gravel.
18'-22' Gravel and boulders.
22'-28' Sand.
28'-38' Sand and water.
38'-43' Gravel and water.



Indicate location of well and place of use, if possible. Each small square represents 40 acres.

Static Water Level for non-flowing well 28 feet.

Shut-in Pressure for Flowing Well.....

Pumping Water Level 28 feet at 15 gal. per minute.

Discharge in gal. per min. of flowing well.....

How Tested pump

Length of Test 1½ hrs.

Remarks: (Gravel packing, cementing, packers, type of shutoff).....

(Continue on reverse side)

USE—If used for irrigation, industrial, drainage or other. Explain, state number of acres and location or other data (i.e.: Lot, Block and Addition).

Show exact depth of bottom.

(5)

Approved Stock Form: State Publishing Co., Helena, Montana—4047.

File No. _____ T 32 N R 34 W

DUPLICATE County Lincoln

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
OFFICE OF STATE ENGINEER

Top of Ground

(Elev. above sea level.....)

Notice of Completion of Groundwater Appropriation by Means of Well

(Under Chapter 237, Montana Session Laws, 1961)

0'-1' Top Soil.
1'-10' Clay and gravel.
10'-13' Gravel, clay and boulders.
13'-22' Clay and gravel.
22'-26' Gravel and boulders.
26'-29' Clay and gravel.
29'-35' Sand, gravel and water.
35'-38' Gravel and water.

Owner Ferdinand O. Hauser Address Box 335 Troy

Driller William L. Lake Address Libby, Mont.

Date of Notice of Appropriation of Groundwater.....

Date well started Oct. 10, 1967 Date Completed Oct. 10, 1967

Type of well drilled (dug, driven, bored or drilled) Equipment Used Cherne (Churn, drill, rotary or other)

Water Use: Domestic ☒ Municipal ☐ Other ☐ Irrigation ☐
Industrial ☐ Drainage ☐ Stock ☐

Indicate on the diagram the character and thickness of the different strata met with in drilling, such as soil, clay, shale, gravel, rock or sand, etc. Show depth at which water is encountered, thickness and character of water-bearing strata and height to which water rises in the well.

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS Kind Size	From (Feet)	To (Feet)
6" O.D.	6 5/8" O.D. 13.97 lbs per foot	0'	31'	none		

Static Water Level for non-flowing Well..... 27 ..... feet.

Shut-in Pressure for Flowing Well.....

Pumping Water Level ..... 28 ..... feet at..... 12 ..... gal. per minute.

Discharge in gal. per min. of flowing well.....

How Tested ..... pump ..... Length of Test..... 2 hrs.

Remarks: (Gravel packing, cementing, packers, type of shutoff, location of place of use of groundwater if not at well, and any other similar pertinent information, including number of acres irrigated, if used for irrigation).....

N W E

Show location of well and place of use, if possible. Each small square represents 10 acres.

Show exact depth of bottom.

152
Driller's License Number

William L. Lake
Driller's Signature

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder

GW No. 905 Nov 2-73

File No. [illegible]

STATE OF MONTANA
Department of Natural Resources and Conservation

WHITE—DEPARTMENT
PINK—BUREAU
CANARY—WELL OWNER
GOLDENROD—DRILLER

WELL LOG REPORT

Notice: Failure to furnish all information requested may result in delay in approving this report. See instructions on reverse side of this form. Please type or print. Submit to Department of Natural Resources and Conservation, 32 South Ewing, Helena, Montana 59601, within 20 days after completion of well.

1. WELL OWNER: Name Robert Montagne Address [illegible], Montana 59935

2. WELL LOCATION: County Lincoln [illegible] Sec. 22, Twp. 32 N-X, Rge. 34 X-W

3. PROPOSED USE: [x] Domestic [ ] Municipal [ ] Industrial [ ] Lawn and Garden
[ ] Irrigation [ ] Stock [ ] [illegible]

4. METHOD DRILLED: [ ] Cable [ ] [illegible]
[x] Forward Rotary [ ] Reverse Rotary
[ ] Jetted [ ] Other (specify)

5. WELL CONSTRUCTION:
Diameter of hole 6 5/8 inches. Depth 43 ft.
Casing: [x] Steel [ ] Plastic [ ] Concrete
[ ] Threaded [x] Welded [ ] Other (specify)

Pipe Weight/Dia.	From	To
17.00 lb/ft. 6 ID inches	0 feet	43 feet
lb/ft. inches	feet	feet
lb/ft. inches	feet	feet

Was perforated pipe used? [ ] Yes [x] No
Length of pipe perforated feet
Was casing left open end? [x] Yes [ ] No
Was a well screen installed? [ ] Yes [x] No
Material Dia. inches
(stainless steel, fiberglass, etc.)
Perforation type: slots holes
Size set from feet to feet
Size set from feet to feet
Size set from feet to feet
Was a packer or seal used? [ ] Yes [x] No
If so, what material
Well type: Straight [illegible]
Was the well grouted? [ ] Yes [x] No
To what depth feet
Material used in grouting
Well head completion: Pitless adapter [illegible]
12" above grade [x] [illegible]
(If pitless adapter or above grade, skip rest of this section)
Was the well disinfected? [x] Yes [ ] No

6. WATER LEVELS:
Static water level 16 ft. above land surface
If flowing, closed-in pressure [illegible] psi
GPM flow through [illegible] pipe
Controlled by: [ ] Valve [ ] Reducer
[ ] Other, specify

7. WELL TEST DATA: [ ] Pump [ ] Bailer [x] Other (If other, specify) air compressor
Pumping level below land surface
40 ft. after 1 hrs. pumping 25 gpm
[ ] ft. after [ ] hrs. pumping [ ] gpm

From	To	Formation
0	1	Top soil.
1	28	Sand, Clay and Gravel.
28	43	Hard Sand, Gravel and Water.

8. [illegible] April 7, 1975

9. [illegible] April 7, 1975

10. [illegible] [ ] Yes [x] No
If yes, [illegible]

11. I hereby certify that this well was drilled under my jurisdiction and this report is true to the best of my knowledge.

R. & R. Drilling Co. 152
Driller's Name Driller's Lic. No.

P. O. Box 847, Libby, Montana 59923
Address

Wm D Labe May 11, 1975
Signature Date

OW 2

Approved Stock Form—State Publishing Co., Helena, Montana—48357

File No. ....

T. 32 R. 34

DUPLICATE

County Lincoln

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
STATE WATER CONSERVATION BOARD

LOG

Top of Ground

(Elev. above sea level ....)

Notice of Completion of Groundwater Appropriation by Means of Well

DEVELOPED AFTER JANUARY 1, 1962

(Under Chapter 237 Montana Session Laws, 1961, as amended)

0'- 1'	Topsoil.
1'-18'	Loose Sand, Gravel and Clay.
18'-24'	Tight Clay and Gravel.
24'-30'	Loose Sand and Gravel.
30'-40'	Sand and Water.
40'-43'	Gravel with Water.

Owner Robert I. Uhr Address Rt. 1 Troy Mont

Driller William D. Lake Address Libby, Montana

Date of Notice of appropriation of groundwater ....

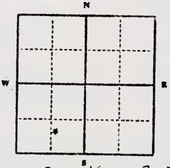
Date well started October 5, 1968 Date completed October 7, 1968

Type of well Drilled (Dug, driven, bored or drilled) Equipment used Churn (Churn drill, rotary or other)

Water use: Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☐ Industrial ☐ Drainage ☐ Other ☐

Indicate on the diagram the character and thickness of the different strata met with in drilling, such as soil, clay, shale, gravel, rock or sand, etc. Show depth at which water is encountered, thickness and character of water-bearing strata and height to which the water rises in the well.

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	Perforations: Kind Size	Perforations: From (Feet)	Perforations: To (Feet)
6" I.D.	6 5/8" O.D. 17.00 lbs. per foot	0	43		none	



Lot 14, Blk. 1, Kootenai Vista

.....¼..... Sec. 22 T. 32 R. 34

Indicate location of well and place of use, if possible. Each small square represents 40 acres.

Static Water Level for non-flowing well 30 feet.

Shut-in Pressure for Flowing Well ....

Pumping Water Level 31 feet at 15 gal. per minute.

Discharge in gal. per min. of flowing well ....

How Tested pump

Length of Test 2 hours

Remarks: (Gravel packing, cementing, packers, type of shutoff) ....

....................(Continue on reverse side)

USE—If used for irrigation, industrial, drainage or other. Explain, state number of acres and location or other data (i.e.: Lot, Block and Addition).

Show exact depth of bottom.

(7)

Depth ... feet
Steel ... Plastic ... Concrete
... Other (if other, specify)

From To
... inches ... feet 140 feet
... inches ... feet ... feet
... inches ... feet ... feet

Was perforated pipe used? x Yes ... No
Length of pipe perforated ... feet
Was casing left open end? ... feet
Was a well screen installed? x Yes ... No
... Yes x No
Material ... Dia. ... inches
(stainless steel, bronze, etc.)
Perforation type ... slots ... holes
Slot or ... size from ... feet to 140 feet
Size ... set from ... feet to ... feet
Size ... set from ... feet to ... feet
Was a packer or seal used? ... Yes x No
If so, what material
Well type: ... straight screen ... Graveled
Was the well grouted? ... Yes ... No
To what depth? ... feet
Material used in grouting
Well head completion: Pitless adapter
12" above grade x ... Other
(If other, specify)
Was the well disinfected? x Yes ... No

From	To	
0		
6	87	
37	140	

(Use separate sheet if necessary)

WATER LEVEL:
Static water level 22 ft. below land surface
If flowing: closed-in pressure ... psi
GPM flow ... through ... inch pipe
Controlled by: ... Valve ... Reducers
... Other, specify

WELL TEST DATA: x Pump ... Bailer ... Other
(If other, specify)
Pumping level below land surface:
27 ft. after 2 hrs. pumping 15 gpm
... ft. after ... hrs. pumping ... gpm

9. DATE STARTED: October 3, 1973

10. DATE COMPLETED: October 5, 1973

11. WAS WELL PLUGGED OR ABANDONED?
If so, how

12. DRILLER'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

B. & R. Drilling Co.
Driller's or Firm Name — License No.

P.O. Box 967 Libby, Montana 59923
Address

Signed by — Date

No. 603 Rev. 7-73

File No. 20327 (9)

STATE OF MONTANA
Department of Natural Resources and Conservation

WELL LOG REPORT

WHITE — DEPARTMENT
PINK — BUREAU
CANARY — WELL OWNER
GOLDENROD — DRILLER

NOV 29 1973

State law requires that this form be filed by the water well driller on any water well completed by him on and after July 1, 1973 within sixty (60) days after completion of the well

WELL OWNER: Name Joe McMillan Address P. O. Box 459 Libby, Montana 59923

WELL LOCATION: County Lincoln NW ¼ NW ¼ SW ¼, Sec. 27, Twp. 22 N-R, Rg. 29 W

PROPOSED USE: x Domestic ___Stock ___Municipal ___Industrial ___Lawn and Garden
___Irrigation ___Other (*if other, specify*)

METHOD DRILLED: ___Cable ___Bored
___Forward Rotary ___Reverse Rotary
___Jetted ___Other (*if other, specify*)

WELL CONSTRUCTION:
Diameter of hole 6 ID inches. Depth 39 ft.
Casing: x Steel ___Plastic ___Concrete
___Threaded x Welded ___Other (*if other, specify*)
Pipe Weight: Dia.: From: To:
17.00 lb/ft. 6 5/8 inches 0 feet 37 feet
___lb/ft. ___inches ___feet ___feet
___lb/ft. ___inches ___feet ___feet
Was perforated pipe used? ___Yes x No
Length of pipe perforated ___ feet
Was casing left open end? x Yes ___No
Was a well screen installed? ___Yes x No
Material ___ Dia. ___ inches
(*stainless steel, bronze, etc.*)
Perforation type: 5/32" slots ___holes
Size x set from 33 feet to 36 feet
Size ___set from ___feet to ___feet
Size ___set from ___feet to ___feet
Was a packer or seal used? ___Yes x No
If so, what material ___
Well type: ___Straight screen ___Gravelled
Was the well grouted? ___Yes x No
To what depth? ___feet
Material used in grouting ___
Well head completion: Pitless adapter ___
12" above grade x Other ___
(*If other, specify*) ___
Was the well disinfected? x Yes ___No

6. WATER LEVEL:
Static water level 27 ft. below land surface
If flowing: closed-in pressure ___psi
GPM flow ___ through ___ inch pipe
Controlled by: ___Valve ___Reducer
___Other, *specify* ___

7. WELL TEST DATA: x Pump ___Bailer ___Other
(*If other, specify*) ___
Pumping level below land surface:
26 (10) ft. after 2 hrs. pumping ___ gpm

8. WELL LOG:

Depth (ft.) From	To	Formation
0	1	Overburden
1	33	Gravel
33	37	Gravel with Water
37	39	Clay

(Use separate sheet if necessary)

9. DATE STARTED: Sept. 7, 1973

10. DATE COMPLETED: Sept. 7, 1973

11. WAS WELL PLUGGED OR ABANDONED? ___Yes x
If so, how ___

12. DRILLER'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

[illegible] Libby, Montana 59923
Address
[illegible] Sept. 7, 1973
Date

Licence No

603 Rev 7-73

RECEIVED

JUL 3 1974

STATE OF MONTANA
Department of Natural Resources and Conservation

WELL LOG REPORT

File No. 9342-76

WHITE—DEPARTMENT
PINK—SUNDRY
CANARY—WELL OWNER
GOLDENROD—DRILLER

NOTICE

te law requires that this form be filed by the water well driller on any water well constructed by him on and after July 1, 1973 within sixty (60) days after completion of the well.

OWNER: Name Stanley T. Kerarr Address Troy, Montana 59935

LOCATION: County Lincoln SE¼ SE¼ NW¼, Sec. 27, Twp. 32 N, Rg. 32 W

USED USE: x Domestic ___Stock ___Municipal ___Industrial ___Lawn and Garden
___Irrigation ___Other (*if other, specify*)

OD DRILLED: ___ Cable ___Bored
Forward Rotary ___Reverse Rotary
Jetted ___Other (*if other, specify*)

CONSTRUCTION:
eter of hole 6 5/8 OD inches. Depth 44 ft.
ng: x Steel ___Plastic ___Concrete
Threaded x Welded ___Other (*if other, ify*)

Weight lb/ft.	Dia.:	From:	To:
6 lb/ft.	6 inches	0 feet	44 feet
___ lb/ft.	___ inches	___ feet	___ feet
___ lb/ft.	___ inches	___ feet	___ feet

perforated pipe used? x Yes ___No
th of pipe perforated 7 feet
asing left open end? x Yes ___No
well screen installed? ___Yes x No
rial ___ Dia. ___ inches
stainless steel, bronze, etc.)
oration type: 3/8"x2" x slots ___holes
32 slots set from 30 feet to 37 feet
___ set from ___ feet to ___ feet
___ set from ___ feet to ___ feet
a packer or seal used? ___Yes x No
o, what material
type: ___Straight screen ___Graveled
the well grouted? ___Yes x No
hat depth? ___ feet
rial used in grouting
head completion: Pitless adapter
above grade x Other
ther, specify)
the well disinfected? x Yes ___No

R LEVEL:
lc water level 31 ft. below land surface
lowing: closed-in pressure ___ psi
flow ___ through ___ inch pipe
rolled by: ___Valve ___Reducers
Other, *specify*

TEST DATA: x Pump ___Bailer ___Other
other, specify)
ing level below land surface:
ft. after 2½ hrs. pumping 10 gpm
ft. after ___ hrs. pumping ___ gpm

8. WELL LOG:

Depth (ft.) From	To	Formation
0	1	Topsoil.
1	22	Clay and Gravel.
22	31	Gravel and Boulders.
31	37	Gravel and Water.
37	44	Sandy Clay.

(*Use separate sheet if necessary*)

9. DATE STARTED: May 24, 1974

10. DATE COMPLETED: May 28, 1974

11. WAS WELL PLUGGED OR ABANDONED? ___Yes x No
If so, how

12. DRILLER'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

B. & B. Drilling Co. 152
Driller's or Firm Name *License No.*

P. O. Box 947 Libby, Montana 59923
Address

Wm D Fake June 29, 1974
Signed By *Date*

Rotary ___ Driven ___
Cable ___ Jetted ___
Reverse Rotary ___
Other (If other, specify) ___

Depth: 12 ft.
Diameter: 8 3/8 inches.
Material: Plastic / Concrete
Steel ___ Wood ___ Other (If other, specify) ___

Type	From	To
Perforations	0 feet	80 feet
Perforations	___ inches	___ feet	___ feet
Perforations	___ inches	___ feet	___ feet

Was perforated pipe used? ___ Yes X No
Length of pipe perforated ___ feet
Was casing left open end? X Yes ___ No
Was well screen installed? ___ Yes X No
Manufacturer's name ___ Dia. ___ inches
(stainless steel, bronze, etc.)
Perforation type: ___ slots ___ holes
Size ___ set from ___ feet to ___ feet
Size ___ set from ___ feet to ___ feet
Size ___ set from ___ feet to ___ feet
Was a packer or seal used? ___ Yes X No
If so, what material ___
Well type: Straight screen ___ Gravelled
Was the well grouted? ___ Yes X No
To what depth? ___ feet
Material used in grouting ___
Well head completion: Pitless adapter ___
12" above grade X Other ___
(If other, specify) ___
Was the well disinfected? X Yes ___ No

6. WATER LEVEL:
Static water level 25 ft. below land surface
If flowing: closed-in pressure ___ psi
GPM flow ___ through ___ inch pipe
Controlled by: ___ Valve ___ Reducers
Other, specify ___

7. WELL TEST DATA: ___ Pump ___ Bailer X Other
(If other, specify) Air Compressor
Pumping level below land surface:
25 ft. after 1 hrs. pumping 15 gpm
___ ft. after ___ hrs. pumping ___ gpm

8. WELL LOG:

Depth (ft.) From	To	Formation
0	1	Topsoil
1	15	Clay and gravel
15	18	Sandstone gravel

(Use separate sheet if necessary)

9. DATE STARTED: June 4, 1971

10. DATE COMPLETED: June 5, 1971

11. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No
If so, how ___

12. DRILLER'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

B. & B. Drilling Co. ___ WD
Driller's or Firm Name ___ License No.

P. O. Box 967 Libby, Montana 59923
Address

Wm D. Bade June 7, 1971
Signed by ___ Date

RECEIVED

File No. (12)

1. Well owner: [illegible] Address: [illegible] Troy, Montana 59935

2. Well location: County [illegible] Sec. 27, Twp. 30 N, Rge. 32 E

3. Proposed use: X Domestic ___ Stock ___ Municipal ___ Industrial ___ Lawn and Garden
___ Irrigation ___ Other (If other, specify)

4. METHOD DRILLED: ___ Cable X Rotary
___ Forward Rotary ___ Reverse Rotary
___ Jetted ___ Other (If other, specify)

5. WELL CONSTRUCTION:
Diameter of hole 10 inches. Depth 34 ft.
Casing: X Steel ___ Plastic ___ Concrete
___ Threaded X Welded ___ Other (If other, specify)
Pipe Weight: Dia. 6 5/8 From: 0 To: 34
18 lb/ft. ___ inches ___ feet ___ feet
___ lb/ft. ___ inches ___ feet ___ feet
___ lb/ft. ___ inches ___ feet ___ feet
Was perforated pipe used? ___ Yes X No
Length of pipe perforated ___ feet
Was casing left open end? X Yes ___ No
Was a well screen installed? ___ Yes X No
Material ___ Dia. ___ inches
(stainless steel, brass, etc.)
Perforation type: ___ slots ___ holes
Size ___ set from ___ feet to ___ feet
Size ___ set from ___ feet to ___ feet
Size ___ set from ___ feet to ___ feet
Was a packer or seal used? ___ Yes X No
If so, what material ___
Well type: ___ Straight Screen ___ Graveled
Was the well grouted? ___ Yes X No
To what depth? ___ feet
Material used in grouting ___
Well head completion: Pitless adapter ___
12" above grade X Other ___
(If other, specify) ___
Was the well disinfected? X Yes ___ No

6. WATER LEVEL:
Static water level 32.4 ft. below land surface
If flowing: closed-in pressure ___ psi
GPM flow ___ through ___ inch pipe
Controlled by: ___ Valve ___ Reducers
___ Other, specify

7. WELL TEST DATA: X Pump X Bailer ___ Other
(If other, specify) ___
Pumping level below land surface:
32 ft. after 12 hrs. pumping 10 gpm
___ ft. after ___ hrs. pumping ___ gpm

8. WELL LOG:

From	To	Formation
0	1	Top soil
1	29	Clay and gravel
29	33'10"	coarse sand and gravel
33'10"	34	sand and fine and gravel with water

This well was dry when drilled but now has water. Water came in when the river was raised.

(Attach additional sheet if necessary)

9. DATE STARTED: Aug. 1, 1975

10. DATE COMPLETED: Sept. 3, 1975

11. WAS WELL PLUGGED OR ABANDONED? ___ Yes X No
If so, how ___

12. CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

McNilan's Drilling 280
Firm Name Licensed No.

Box 608 Troy, Montana 59935
Address

[signature] 9/20/75
Signed by Date

(13)

RM Nov. 1966 Rev 7-73

RECEIVED
NOV 29 1973
MONT. DEPT. of NATURAL RESOURCES & CONSERVATION

1360-g76
File No.

STATE OF MONTANA
Department of Natural Resources and Conservation

WHITE—DEPARTMENT
PINK—BUREAU
CANARY—WELL OWNER
GOLDENROD—DRILLER

WELL LOG REPORT

State law requires that this form be filed by the water well driller on any water well completed by him on and after July 1, 1973 within sixty (60) days after completion of the

1. WELL OWNER: Name John Bramlet Address Troy, Montana 59935

2. WELL LOCATION: County Lincoln NE ¼ SE¼ NW¼, Sec. 27, Twp. 32 N., Rg. 31

3. PROPOSED USE: x Domestic ___Stock ___Municipal ___Industrial ___Lawn and Garden ___Irrigation ___Other (*if other, specify*)

4. METHOD DRILLED: ___Cable ___Bored
x Forward Rotary ___Reverse Rotary
___Jetted ___Other (*if other, specify*)

5. WELL CONSTRUCTION:
Diameter of hole 6 ID inches. Depth 45 ft.
Casing: x Steel ___Plastic ___Concrete
___Threaded x Welded ___Other (*if other, specify*)

Pipe Weight:	Dia.:	From:	To:
17.00 lb/ft.	6 5/8 inches	0 feet	45 feet
___ lb/ft.	___ inches	___ feet	___ feet
___ lb/ft.	___ inches	___ feet	___ feet

Was perforated pipe used? ___Yes x No
Length of pipe perforated ___ feet
Was casing left open end? x Yes ___No
Was a well screen installed? ___Yes x No
Material ___ Dia. ___ inches
(*stainless steel, bronze, etc.*)
Perforation type: ___slots ___holes
Size ___ set from ___ feet to ___ feet
Size ___ set from ___ feet to ___ feet
Size ___ set from ___ feet to ___ feet
Was a packer or seal used? ___Yes x No
If so, what material ___
Well type: ___Straight screen ___Gravel
Was the well grouted? ___Yes x No
To what depth? ___ feet
Material used in grouting ___
Well head completion: Pitless adapter ___
12" above grade x Other ___
(*If other, specify*) ___
Was the well disinfected? x Yes ___No

6. WATER LEVEL:
Static water level 27 ft. below land surface
If flowing: closed-in pressure ___ psi
GPM flow ___ through ___ inch pipe
Controlled by: ___Valve ___Reducers

8. WELL LOG:

Depth (ft.) From	To	Formation
0	1	Topsoil.
1	27	Clay, Gravel and Boulders.
27	45	Sand, Gravel with Water.

(*Use separate sheet if necessary*)

9. DATE STARTED: September 28, 1973

10. DATE COMPLETED: September 29, 1973

11. WAS WELL PLUGGED OR ABANDONED? ___Yes x
If so, how ___

12. DRILLER'S CERTIFICATION:
This well was drilled under my jurisdict
and this report is true to the best of m
knowledge.

E. & R. Drilling Co. 152

gw 1

Approved Stock Form—State Publishing Co., Helena, Montana—4-69. (15)

File No. .....

MONTANA WATER RESOURCES BOARD
RECEIVED
MAR 16 1970

T 31 R 34

County Lincoln

DUPLICATE

LOG

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
STATE WATER CONSERVATION BOARD

Notice of Completion of Groundwater Appropriation by Means of Well

DEVELOPED AFTER JANUARY 1, 1962

(Under Chapter 237 Montana Session Laws, 1961, as amended)

Top of Ground

(Elev. above sea level.....)

0'- 1' Topsoil.

1'-18' Loose sand and Gravel.

18'-21' Clay, Gravel, and Boulders.

21'-28' Loose Gravel.

28'-32' Sand, Gravel and Water.

Owner Steve Vinnie Whitlock Box 252 Troy

Driller William R. Lake Address Libby, Montana

Date of Notice of appropriation of groundwater.....

Date well started November 5, 1969 Date completed November 10, 1969

Type of well Drilled Equipment used Gladen
(Dug, driven, bored or drilled) (Cable tool, rotary or other)

Water use: Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☐
Industrial ☐ Drainage ☐ Other ☐

Indicate on the diagram the character and thickness of the different strata met with in drilling, such as soil, clay, shale, gravel, rock or sand, etc. Also depth at which water is encountered, thickness and character of water bearing strata and height to which the water rises in the well.

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS: Kind	From (Feet)	To (Feet)
6"I.D.	5 5/8"O.D. 17.00 lbs. per foot	0	32		None	

Doc. No. 729
Filed for record this 6 day of March A.D. 19 70 at 3:50 o'clock P.M.

N
W E
S

Static Water Level for non-flowing well 27 feet

Shut-in Pressure for Flowing Well .....

Pumping Water Level 30 feet at 15 gal. per minute.

Discharge in gal. per min. of flowing well .....

How Tested Pump

Length of Test 1 Hour

Remarks: (Gravel packing, cementing, packers, type of shutoff).....

.....

.....

.....

.....(Continue on reverse side)

USE—If used for irrigation, industrial, drainage or other. Explain, state number of acres and location or other data (i.e.: Lot, Block and Addition).

.....

.....

Show exact depth of bottom.

Kilbo Estates Unit 2
NE 1/4 Sec. 27 T. 31 R. 34
Indicate location of well and place of use, if possible. Each small square represents 40 acres.

This form to be prepared by driller, and three copies to be filed by the owner with the [illegible] of the county in which the well is located, tissue copy to be

152
Driller's License Number

STATE OF MONTANA

White Department
Yellow Department
Pink Well Owner
Gold Driller

(16)

1) Well owner: Melvin Jellesec

2) Well owner's address: Box 204, Troy, Montana 59935

3) PROPOSED USE: irrigation ... domestic ... municipal ... industrial

4) WELL LOCATION:

SW ¼ SE ¼ NW ¼ Section 27
T 32 N R 34 W N or S E or W
OR, Lot 2 Block 4
Subdivision Kootenai Vista
City Troy County Lincoln
Elevation ... Accuracy ... ±10 ... ±50 ... ±100

5) DRILLING METHOD: X cable ... bored, ... forward rotary, ... reverse rotary ... jetted, ... other (specify)

6) WELL CONSTRUCTION AND COMPLETION

Size of drilled hole	Size and weight of casing	From feet	To feet	Perforations	Screens
6"I.D.	6 5/8"O.D. 17.00 lbs. per ft.	0	200	none	

Was casing left open end? X Yes ... No
Was a packer or seal used? ... Yes X No
If so, what material ...
Was the well gravel packed? ... Yes X No
Was the well grouted? ... Yes X No
To what depth? sealed with drill cuttings
Material used in grouting ...
Well head completion: Pitless adapter ...
12 in. above grade X other ...
(if other, specify) ...
Pump: horsepower ... pump type ...
Pump intake level ... feet below land surface
Power (electric, diesel, etc.) ...

7) WELL TEST DATA: ... bailer ... other
(if other, specify) ...
Pumping level below land surface
ft. after ... hrs. pumping ... gpm
ft. after ... hrs. pumping ... gpm

8) WAS WELL PLUGGED OR ABANDONED? ... Yes X No
If yes, how? ...

10) DATE STARTED May 8, 1978
DATE COMPLETED May 18, 1978

11) WELL LOG

Depth (ft.) From	To	Formation
0	6	Sandy Clay.
6	7	Gravel.
7	26	Sandy Clay.
26	32	Sand.
32	170	Clay.
170	171	Sand.
171	183	Clay.
183	191	Gravel.
191	195	Clay.
195	200	Coarse Sand with Water.

(use separate sheet if necessary)

12) DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge
Date June 6, 1978
E. & E. Drilling Co.
(name)

File No. 2760

(17)

WELL LOG REPORT

1. Well owner: [illegible] Address: [illegible], Montana 59935

2. Well location: [illegible] NE SE 27 32 S. R. 34 E. C

3. Proposed use: [illegible]

4. Method of drilling:
[illegible] Driving
[illegible] Jetted [illegible]

5. Well construction:
Diameter of hole 6 inches. Depth 77'6"
Casing: X Steel [illegible] Plastic [illegible]
[illegible] Threaded X Welded [illegible]
(Type)
Pipe Weight/Wall: From To
17 lb/ft. [illegible] inches 0 feet [illegible] feet
[illegible] lb/ft. [illegible] inches [illegible] feet [illegible] feet
[illegible] lb/ft. [illegible] inches [illegible] feet [illegible] feet
Was perforated pipe used? [illegible] Yes [illegible] No
Length of pipe perforated [illegible] feet
Was casing left open end? X Yes [illegible] No
Was a well screen installed? [illegible] Yes X No
Material [illegible] Dia. [illegible] inches
(stainless steel, brass, etc.)
Perforation type: [illegible] slots [illegible] holes
Size [illegible] set from [illegible] feet to [illegible] feet
Size [illegible] set from [illegible] feet to [illegible] feet
Size [illegible] set from [illegible] feet to [illegible] feet
Was a packer or seal used? [illegible] Yes X No
If so, what material [illegible]
Well type: [illegible] Straight [illegible] (if known)
Was the well grouted? [illegible] Yes X No
To what depth? [illegible] feet
Material used in grouting [illegible]
Well head completion: [illegible]
12" above grade X [illegible]
(if other, explain)
Was the well disinfected? X Yes [illegible] No

6. Water Level:
Static water level 27 ft. above [illegible]
If flowing: closed-in pressure [illegible] psi
GPM flow [illegible] through [illegible] inch opening
Controlled by: [illegible] Valve [illegible] Fittings
[illegible] Other, specify

7. Well test: [illegible] Test [illegible] Test
(If other, explain)
Pumping level [illegible] hours
29 ft. after 1 hours pumping 12 GPM
[illegible] ft. after [illegible] hours pumping [illegible] GPM

Formation
[illegible] Clay, soil
[illegible] Gray sand and gravel
[illegible] Water bearing sand

RECEIVED
JUL 7 1975
MONT. DEPT. OF NATURAL RESOURCES & CONSERVATION

Date well drilling began June 10, 1975
Date well completed June 11, 1975
Did any water quality problem exist? [illegible] Yes X No
If so, explain

The above well was drilled under my jurisdiction and this report is true to the best of my knowledge.

[illegible] Drilling 200
Drilling Co. Address

[illegible], Montana 59935

[illegible] 6/30/75
Signature Date

(4 CSRV 75)

STATE OF MONTANA
Department of Natural Resources and Conservation

WELL LOG REPORT

File No. 18

White-Department
Pink-Bureau
Yellow-Well owner
Gold-Driller

110/1
976D

MONTANA WELL DRILLERS ASSOCIATION

Law requires that this form be filed by the owner or driller with 60 days after completion of the well, and that a copy of this report be furnished to the owner. Filed by the well owner within 60 days of completion of the well, and that a copy of this report be furnished to the owner. Failure to do so is a misdemeanor.

WELL OWNER Name Robert White — Current address Troy, Montana 59935

WELL LOCATION Lot ____, Block ____, Subdivision ____
County Lincoln, or NW ¼ NE ¼ SE ¼ Sec. 27, T. 32 N-S, R. 34 E-W

3. PROPOSED USE
x domestic (includes lawn and garden); ____ stock; ____ municipal;
____ industrial; ____ irrigation; ____ other (specify) ____

4. METHOD DRILLED
____ cable, ____ bored,
x forward rotary, ____ reverse rotary,
____ jetted, ____ other (specify) ____

5. WELL CONSTRUCTION
Diameter of hole 6 5/8" O.D. depth 325 ft.
Casing: x steel, ____ plastic, ____ concrete,
____ threaded, x welded, ____ other (specify)

Pipe weight:	Dia.	From	To
17.00 lb/ft	6" I.D. in.	0 ft.	11 ft.
____ lb/ft	____ in.	____ ft.	____ ft.

Was casing left open end? x Yes ____ No
Was a well screen installed? ____ Yes x No
Material ____, dia. ____ in.
(stainless steel, bronze, etc.)
Was perforated pipe used? ____ Yes x No
Perforation type: ____ slots ____ holes
Size ____ set from ____ ft. to ____ ft.
Size ____ set from ____ ft. to ____ ft.
Was a packer or seal used? x Yes ____ No
If so, what material Bentonite
Well type: Straight screen ____ Gravel
Was the well grouted. ____ Yes x No
To what depth: ____ ft.
Material used in grouting ____
Well head completion: Pitless adapter ____
12 in. above grade x, other ____
(if other, specify) ____
Was well disinfected? x Yes ____ No

6. WATER LEVEL
Static water level 150 ft. below land surface
If flowing: closed-in pressure ____ psi
gpm flow ____ through ____ inch pipe
Controlled by: ____ valve, ____ reducers
____ other (specify) ____

7. WELL TEST DATA ____ Pump ____ Bailer x Other
(if other, specify) air compressor
Pumping level below land surface:
200 ft. after 1 hrs. pumping 150 gal. Flowing gpm
____ ft. after ____ hrs. pumping ____ gpm

8. WELL LOG

Depth (ft) From	To	Formation
0	6	Sand.
6	150	Solid Rock.(gray-green)
150	165	Fractured Solid Rock.
165	210	Solid Rock.
210	286	Softer Rock with fractures.
286	305	Hard Solid Rock.
305	325	Softer, fractured Rock.

(use separate sheet if necessary)

9. DATE STARTED Oct. 6, 1976
DATE COMPLETED October 19, 1976

10. WAS WELL PLUGGED OR ABANDONED? ____ Yes x No
If so, how?

11. DRILLER'S CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge.

R. & B. Drilling Co. 152
Driller's or firm name License No.

P. O. Box 967, Libby, Montana 59923
Address

Wm D Fobb October 25, 19
Signed by date

Form No. 603 (Rev. 8/75)

File No. 125796

STATE OF MONTANA
Department of Natural Resources and Conservation

White-Department
Pink-Bureau
Yellow-Well owne
Gold-Driller

WELL LOG REPORT

State law requires that this form be filed with the [illegible] within 60 days after completion of the well. [illegible] Conservation Department, be filed by the [illegible] use.

1. WELL OWNER
Name John B. Dillon
Street address Sylvanite Ranger Station, Troy, Mt.599

2. WELL LOCATION Lot ____, Block ____, Subdivision ____
County Lincoln, NE ¼ NE ¼ Sec. 27, Twp. 32 N., Rge. 34 W.

3. PROPOSED USE ___x___ domestic (indicate if also used for stock); ____ municipal
____ industrial; ____ irrigation; ____ other (specify)

4. METHOD DRILLED ____ cable, ____ hydraulic,
___x___ forward rotary, ____ reverse rotary,
____ jetted, ____ other (specify)

5. WELL CONSTRUCTION
Diameter of hole 6"I.D. in.; depth 30 ft.
Casing: ___x___ steel, ____ plastic, ____ concrete,
____ threaded, ___x___ welded, ____ other (specify)

Pipe weight:

	Dia.	From	To
19.00 lb/ft	6 5/80.D.	0 ft.	30 ft.
____ lb/ft	____ in.	____ ft.	____ ft.

Was casing left open end? ___x___ Yes ____ No
Was a well screen installed? ____ Yes ___x___ No
Material ____, dia. ____ in.
(stainless steel, bronze, etc.)
Was perforated pipe used? ___x___ Yes ____ No
Perforation type 3/8x2½ slots ____ holes
Size 32slots set from 17 ft. to 24 ft.
Size ____ set from ____ ft. to ____ ft.
Was a packer or seal used: ____ Yes ___x___ No
If so, what material ____
Well type: ____ Straight screen ____ gravel
Was the well grouted: ____ Yes ___x___ No
To what depth: ____ ft.
Material used in grouting ____
Well head completion: ____ pitless adapter
12 in. above grade ___x___, other ____
(if other, specify) ____
Was well disinfected? ___x___ Yes ____ No

6. WATER LEVEL
Static water level 12 ft. below land surface
If flowing: closed-in pressure ____ psi
____ gpm flow ____ through ____ inch pipe
Controlled by: ____ valve ____ orifice
____ other (specify) ____

7. WELL TEST DATA ____ Pump ____ Bailer ___x___ Other
(if other, specify) air compressor
Pumping level below land surface:
____ ft. after 2 hrs. pumping 10 gpm
____ ft. after ____ hrs. pumping ____ gpm

8. Drillers Log

From	To	Formation
0	1	Topsoil.
1	16	Clay, Gravel, and Boulders.
16	24	Gravel, Sand, and Water.
24	36	Sand.

(Use separate sheet if necessary)

9. DATE STARTED July 22, 1976
DATE COMPLETED July 23, 1976

10. WAS WELL USED AT TIME OF ABANDONMENT? ____ Yes ___x___
If yes, explain ____

11. CERTIFICATION
I [illegible] drilled under my jurisdiction and this report is true to the best of my knowledge.

E. & P. Drilling Co. 152
Driller's or firm name License No.

P. O. Box 967, Libby, Montana 59923
Address

Signed by [signature] September 7, 19[illegible]
date

(20)

GW 2

Approved Mont. Form—Weir Publishing Co., Helena, Montana—4132.

File No.

DUPLICATE

MONTANA WATER RESOURCES BOARD
RECEIVED
JUL 14 1969

T.... R....

County Lincoln

LOG

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
OFFICE OF STATE ENGINEER

Top of Ground

(Elev. above sea level.....)

Notice of Completion of Groundwater Appropriation by Means of Well

DEVELOPED AFTER JANUARY 1, 1962

(Under Chapter 237, Montana Session Laws, 1961)

0'-18' Sand and gravel with hard layers.

18'-21' Hard pan.

21'-27' Clay and gravel.

27'-29' Gravel

29'-35' Sand and gravel with water.

Owner [illegible] Address Libby, Montana

Driller Willis Sanders Address Libby, Montana

Date of Notice of appropriation of groundwater.....

Date well started June 7 Date completed July 15, 1962

Type of well Drive Equipment used Pump
(Dug, Driven, bored or drilled) (Churn drill, rotary or other)

Water use: Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☐
Industrial ☐ Drainage ☐ Other ☐

Indicate on the diagram the character and thickness of the different strata met with in drilling, such as soil, clay, shale, gravel, rock or sand, etc. Show depth at which water is encountered, thickness and character of water-bearing strata and height to which the water rises in the well.

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS: Kind Size	From (Feet)	To (Feet)
7 3/4	5 5/8 O.D. 17.11 lbs per foot	0'	25'	None		

N / W / E

Lot 13 River Bend Homes
¼ Sec. 27 T. 32 R. 34

Indicate location of well and place of use, if possible. Each small square represents 40 acres.

Static Water Level for non-flowing well 21 feet.

Shut-in Pressure for Flowing Well.....

Pumping Water Level 32 feet at 10 gal. per minute.

Discharge in g.p.m. per min. of flowing well.....

How Tested Pump

Length of Test 4 hours

Remarks: (Gravel packing, cementing, packers, type of shutoff).....

.....(Continue on reverse side)

USE—If used for irrigation, industrial, drainage or other. Explain, state number of acres and location or other data (i.e.: Lot, Block and Addition).

Show exact depth of bottom.

(21)

...W-2 Revised 1968

County Lincoln

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
MONTANA WATER RESOURCES BOARD

NOTICE OF COMPLETION OF GROUNDWATER APPROPRIATION BY MEANS OF WELL

Developed after January 1, 1962

(Under Chapter 237 Montana Session Laws, 1961, as amended)

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder in the county in which the well is located, last copy to be retained by driller.

Please answer all questions. If not applicable, so state, otherwise the form may be returned.

Owner Keith Hubert (1) 11-4-77

Address ...Troy, Montana

Date well started May 19, 1970

completed May 21, 1970

For Administrator's Use
File
GW I

Type of well Drilled
(Dug, driven, bored or drilled)

Equipment used Churn Drill
(Cherry drill, rotary or other)

Water Use: Domestic ☑ Municipal ☐ Stock ☐ Irrigation ☐

Industrial ☐ Drainage ☐ Other ☐* Garden/Lawn ☐

*Describe .....

USE: If used for Irrigation, Industrial, drainage or other. Explain, state number of acres and location or other data (i.e. Lot, Block and Addition).

ESTIMATED ANNUAL WITHDRAWAL ...75,000 ...a

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS		
				Kind Size	From (Feet)	To (Feet)
6"I.D.	6 5/8"O.D. 17.00 lbs. per foot	1	24	Screen		

Static water level 23 ft.*
Pumping water level 24 ft.*
at 45 gallons per minute,
measured 30 minutes after pumping began.
*Measured from ground level.
Well developed by Pump
for 4 hours.
Power Electric Pump ½ HP
Remarks: (Gravel packing, cementing packers, type of shutoff)

NW ¼ SE ¼ Sec. 27
T. 32 N R. 32 E
S W

INDICATE LOCATION OF WELL AND PLACE OF USE, IF POSSIBLE
EACH SMALL SQUARE REPRESENTS 40 ACRES.

Driller's Signature ...

DRILLER'S LOG

Indicate the character, color, thickness of strata such as soil, clay, sand, gravel, shale, sandstone, etc. Show depth at which water is found and height to which water rises in well.

Top of Ground (Elev. above sea level)

From (Feet)	To (Feet)	
1	12	Clay and Gravel with Sand-fill.
12	23	Clay and gravle.
23	32	Sand, gravel, with Water.

GW 2 — Approved Stock Form—State Publishing Co., Helena, Mont. (22)

File No. — STATE WATER CONSERVATION BOARD — T 32 R 26

DUPLICATE — JUL 6 1966 — County Lincoln

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
OFFICE OF STATE ENGINEER

Top of Ground
(Elev. above sea level [illegible])

Notice of Completion of Groundwater Appropriation by Means of Well

(Under Chapter 237, Montana Session Laws, 1961)

0'-12' Loose clay and gravel.
12'-21' Tight clay and gravel.
21'-28' Loose clay and gravel.
28'-35' Tight clay and gravel.
35'-40' Gravel and water.

Owner U. K. Cushnell Address Troy, Mont.

Driller William D. Lake Address Libby, Mont.

Date of Notice of Appropriation of Groundwater

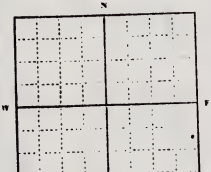
Date well started June 13, 1966 Date Completed June 14, 1966

Type of well drilled (dug, driven, bored or drilled) Equipment Used Churn (Churn, drill, rotary or other)

Water Use: Domestic ☒ Municipal ☐ Other ☐ Irrigation ☐
Industrial ☐ Drainage ☐ Stock ☐

Indicate on the diagram the character and thickness of the different strata met with in drilling, such as soil, clay, shale, gravel, rock or sand, etc. Show depth at which water is encountered, thickness and character of water-bearing strata and height to which water rises in the well.

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS		
				Kind Size	From (Feet)	To (Feet)
6" I.D.	18.97 lbs. per foot 6⅝" O.D.	0'	40'	none		



Each 2cm Blk Sq. Represents Acres

¼ ¼ Sec. T R
Indicate location of well and place of use, if possible. Each small square represents 10 acres.

Show exact depth of bottom.

Static Water Level for non-flowing Well 26 feet.

Shut-in Pressure for Flowing Well

Pumping Water Level 28 feet at 8 gal. per minute.

Discharge in gal. per min. of flowing well

How Tested pump Length of Test 16 hr.

Remarks: (Gravel packing, cementing, packers, type of shutoff, location of place of use of groundwater if not at well, and any other similar pertinent information, including number of acres irrigated, if used for irrigation)

152
Driller's License Number

William D. Lake
Driller's Signature

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder in the county in which the well is located

(23)

GW 1 — Approved Stock Form—State Publishing Co., Helena, Montana—4x55

File No. .....

DUPLICATE

T. 32 R. 34

County Lincoln

LOG

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
STATE WATER CONSERVATION BOARD

Notice of Completion of Groundwater Appropriation by Means of Well

DEVELOPED AFTER JANUARY 1, 1962

(Under Chapter 237 Montana Session Laws, 1961, as amended)

Top of Ground

(Elev. above sea level.....)

0' - 1' Topsoil.

1' - 14' Loose Gravel.

14' - 34' Tight Clay, Gravel, and Boulders.

34' - 38' Sand, Gravel, and Water.

Owner Mel Blakemagh Address R. 1 Troy, Mont.

Driller William D. Lake Address Libby, Montana

Date of Notice of appropriation of groundwater.....

Date well started Sept. 10, 1969 Date completed September 12, 1969

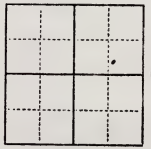
Type of well Drilled Equipment used Chore
(Dug, driven, bored or drilled) (Chore drill, rotary or other)

Water use: Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☐
Industrial ☐ Drainage ☐ Other ☐

MONTANA WATER RESOURCES BOARD
RECEIVED
NOV 17 1969

Indicate on the diagram the character and thickness of the different strata met with in drilling, such as soil, clay, shale, gravel, rock or sand, etc. Show depth at which water is encountered, thickness and character of water-bearing strata and height to which the water rises in the well.

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS		
				Kind Size	From (Feet)	To (Feet)
6" I. D.	6 5/8" O.D. 17.00 lbs. per foot	0	38		None	



Lot 4 Section of Home

NW SE ¼ Sec. 17 T. 32 R. 34

Indicate location of well and place of use, if possible. Each small square represents 40 acres.

Static Water Level for non-flowing well 32 feet.

Shut-in Pressure for Flowing Well.....

Pumping Water Level 33 feet

at 10 gal. per minute.

Discharge in gal. per min. of flowing well .....

How Tested Bailer

Length of Test 2 Hours

Remarks: (Gravel packing, cementing, packers, type of shutoff).....

(Continue on reverse side)

USE—If used for irrigation, industrial, drainage or other. Explain, state number of acres and location or other data (i.e.: Lot, Block and Addition).

Show exact depth of bottom.

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder in the county in which the well is located within 60 days.

152

Driller's Log No.

NOTICE OF COMPLETION OF GROUNDWATER APPROPRIATION BY MEANS OF WELL

Developed after January 1, 1962

(Under Chapter 237 Montana Session Laws, 1961, as amended)

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder in the county in which the well is located, last copy to be retained by driller.

Please answer all questions. If not applicable, so state, otherwise the form may be returned.

Owner: Lloyd B. Mitchell

Address: 603 Calif

Libby, Montana

Date well started 5-21-71

completed 5-22-71

For Administrator's Use
File 703
July 5, 1971
3:45 P.M.
GW 1

Type of well: drilled (Dug, driven, bored or drilled)

Equipment used: Rotary (Cable drill, rotary or other)

Water Use: Domestic [X] Municipal [ ] Stock [ ] Irrigation [ ]

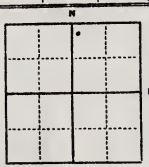
Industrial [ ] Drainage [ ] Other [ ]* Garden/Lawn [ ]

*Describe .....

USE: If used for irrigation, Industrial, drainage or other. Explain, state number of acres and location or other data (i.e. Lot, Block and Addition). .....

ESTIMATED ANNUAL WITHDRAWAL .....

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS Kind Size,	From (Feet)	To (Feet)
6"	6" 17#	0	33	½ Round	C	4'



AENW½ NW¼NE¼ Sec. 35
T. 32 N R. 32 W

Static water level ..... 15 ..... ft.*
Pumping water level ..... 10 ..... ft.*
at ..... 10 ..... gallons per minute,
measured ..... minutes after pumping
began.
*Measured from ground level.
Well developed by .....
for ..... hours
Power..... Pump..... HP
Remarks: (Gravel packing, cementing, packers, type of shutoff) .....

INDICATE LOCATION OF WELL AND PLACE OF USE, IF POSSIBLE. EACH SMALL SQUARE REPRESENTS 40 ACRES.

Driller's Signature: Clifford Faucher

Driller's Address: Box 2

Libby, Montana LICENSE NO. 141

gravel, shale, sandstone, etc. Show depth at which water is found and height to which water rises in well.

Top of Ground (Elev. above sea level) _____

From (Feet)	To (Feet)	
0	4	Red Clay
4	17	Sandy Clay
17	30	Gravel
30	33	Gravel & sand

33' Show exact depth of bottom

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
OFFICE OF STATE ENGINEER

Notice of Completion of Groundwater Appropriation by Means of Well

(Under Chapter 237, Montana Session Laws, 1961)

Top of Ground

(Elev. above sea level 1900)

0'-1' Topsoil.
1'-20' Clay, gravel, sand and boulders.
20'-26' Loose clay and gravel.
26'-40' Clay, gravel, sand, some water.
40'-46' Clay and gravel.
46'-50' Sand, gravel with water.

Owner [illegible] Address Box 532 Troy, Mont.

Driller William D. Fake Address Libby, Mont.

Date of Notice of Appropriation of Groundwater .....

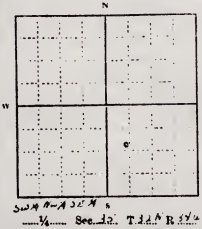
Date well started Jan. 13, 1967 Date Completed Jan. 20, 1967

Type of well drilled (dug, driven, bored or drilled) Equipment Used churn (Churn, drill, rotary or other)

Water Use: Domestic ☒ Municipal ☐ Other ☐ Irrigation ☐
Industrial ☐ Drainage ☐ Stock ☐

S-1 Indicate on the diagram the character and thickness of the different strata met with in drilling, such as soil, clay, shale, gravel, rock or sand, etc. Show depth at which water is encountered, thickness and character of water-bearing strata and height to which water rises in the well.

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS Kind Size	PERFORATIONS From (Feet)	PERFORATIONS To (Feet)
6" O.D.	6 5/8" O.D. 18.97 lbs per foot	0'	50'	none		



SW ¼ NE ¼ Sec. 32 T 33 N R 32 W

Indicate location of well and place of use, if possible. Each small square represents 10 acres.

Show exact depth of bottom.

Static Water Level for non-flowing Well 26 feet.

Shut-in Pressure for Flowing Well .....

Pumping Water Level 27 feet at 12 gal. per minute.

Discharge in gal. per min. of flowing well .....

How Tested Bailed Length of Test 1 hr.

Remarks: (Gravel packing, cementing, packers, type of shutoff, location of place of use of groundwater if not at well, and any other similar pertinent information, including number of acres irrigated, if used for irrigation) .....

152
Driller's License Number

Wm D. Fake
Driller's Signature

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder in the county in which the well is located

Please answer all questions. If not applicable, so state, otherwise the form will be returned.

Original to the County Clerk and Recorder; duplicate to the State Engineer; Triplicate to the Montana Bureau of Mines and Geology and Quadruplicate for the Appropriator.

(1-77)

(26)

...m 3 GW 2 Revised 1969
State Publishing Company

County Lincoln

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
MONTANA WATER RESOURCES BOARD

NOTICE OF COMPLETION OF GROUNDWATER APPROPRIATION BY MEANS OF WELL

Developed after January 1, 1962

(Under Chapter 237 Montana Session Laws, 1961, as amended)

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder in the county in which the well is located, last copy to be retained by driller.

Please answer all questions. If not applicable, so state, otherwise the form may be returned.

Owner ...Frankie Kinney

Address ...Troy, Montana

For Administrator's Use
File 103
Date 2, 1971
12:50 P.M.
GW 1

Date well started January 22, 1971
completed February 13, 1971

Type of well ...Drilled (Dug, driven, bored or drilled)

Equipment used ...Chara (Chara drill, rotary or other)

Water Use: Domestic ■ Municipal ☐ Stock ☐ Irrigation ☐
Industrial ☐ Drainage ☐ Other ☐* Garden/Lawn ☐

*Describe

USE: If used for irrigation, industrial, drainage or other. Explain, state number of acres and location or other data (i.e. Lot, Block and Addition).

ESTIMATED ANNUAL WITHDRAWAL ...100, 000 gal.

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS Kind Size	From (Feet)	To (Feet)
6" I.D.	5 5/8" O. D. 17.00 lbs. per foot	0	146	Non.		

Top of Ground (Elev. above sea level)

From (Feet)	To (Feet)	
0	1	Topsoil
1	7	Clay, Gravel and Boulders.
7	17	Clay and Gravel.
17	70	Sand.
70	80	Sand and some Gravel.
80	110	Layers of Clay, Sand, Gravel.
110	146	Gravel and Water.

DRILLER'S LOG

Indicate the character, color, thickness of strata such as soil, clay, sand, gravel, shale, sandstone, etc. Show depth at which water is found and height to which water rises in well.

N
W E

Static water level 22 ft.*
Pumping water level 80 ft.*
at 10 gallons per minute,
measured 11 hours after pumping began.
*Measured from ground level.
Well developed by Pump
for 12 hours
Power... elec. Pump... 1 HP

NOTICE OF COMPLETION OF GROUNDWATER APPROPRIATION BY MEANS OF WELL

Developed after January 1, 1962

(Under Chapter 237 Montana Session Laws, 1961, as amended)

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder in the county in which the well is located, last copy to be retained by driller.

Please answer all questions. If not applicable, so state, otherwise the form may be returned.

Owner Wm. Deshnell

Address Troy, Montana

Date well started Sept. 25, 1970

completed Sept. 30, 1970

For Administrator's Use

File 151

Nov 17 1970 10:15 a.m.

GW 1

Type of well drilled (Dug, driven, bored or drilled)

Equipment used Chara (Chara drill, rotary or other)

Water Use: Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☐

Industrial ☐ Drainage ☐ Other ☐* Garden/Lawn ☐

*Describe

USE: If used for irrigation, industrial, drainage or other. Explain, state number of acres and location or other data (i.e. Lot, Block and Addition).

ESTIMATED ANNUAL WITHDRAWAL 80,000 Gal.

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS		
				Kind Size	From (Feet)	To (Feet)
6" I.D.	5/32" O.D. 17.00 lbs. per ft.	0	60	None		

N

W E

S

Static water level 39 ft.*

Pumping water level 44 ft.*

at 35 gallons per minute, measured 60 minutes after pumping began.

*Measured from ground level.

Well developed by Pump for 2 hours.

Power elec. Pump 1 HP

Remarks: (Gravel packing, cementing, packers, type of shutoff)

SE ¼ NW ¼ Sec. 12

T. 31 N R. 34 E W

INDICATE LOCATION OF WELL AND PLACE OF USE, IF POSSIBLE. EACH SMALL SQUARE REPRESENTS 40 ACRES.

Driller's Signature Troy L. Fehr

Driller's Address P.O. Box 967, Libby, Mont.

LICENSE NO. 132

Top of Ground (Elev. above sea level)

From (Feet)	To (Feet)	
0	3	topsoil
3	23	Clay, gravely and bouldery
23	44	Light colored sandy gravel,
44	60	sandy Gravel with waters

Show gravel, shale, sandstone, etc. Show depth at which water is found and height to which water rises in well.

(27)

60 Show exact depth of bottom

417990

(28)

GW 2

Approved Stock Form—State Publishing Co., Helena, Montana

File No. .....

MONTANA WATER RESOURCES BOARD
RECEIVED
FEB 26 1970

T. 31 R. 34

County Lincoln

DUPLICATE

LOG

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
STATE WATER CONSERVATION BOARD

Notice of Completion of Groundwater Appropriation by Means of Well

DEVELOPED AFTER JANUARY 1, 1962

(Under Chapter 237 Montana Session Laws, 1961, as amended)

Top of Ground

(Elev. above sea level.....)

0' - 1' Topsoil.

1' - 11' Sand, Gravel, and Clay.

11' - 51' Dry Sand.

51' - 90' Sand, Silt, and Water.

90' - 93' Sand, Gravel, with Water.

Owner Larry D. Knoepke Address Troy, Montana

Driller William D. Lake Address Libby, Montana

Date of Notice of appropriation of groundwater.....

Date well started July 17, 1969 Date completed July 24, 1969

Type of well Drilled Equipment used Cable
(Dug, driven, bored or drilled) (Churn drill, rotary or other)

Water use: Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☐
Industrial ☐ Drainage ☐ Other ☐

Indicate on the diagram the character and thickness of the different strata met with in drilling, such as soil, clay, shale, gravel, rock or sand, etc. Show depth at which water is encountered, thickness and character of water-bearing strata and height to which the water rises in the well.

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS Kind Size	From (Feet)	To (Feet)
6" I. D.	6 5/8" O.D. 17.00 lbs. per foot	0	93	None		

Doc. No. 127
Filed for record this 13 day of February A. D. 19 1970 at 11:57 o'clock A.M.

N
W E
S
+

LOT 6

Static Water Level for non-flowing well 51 feet.

Shut-in Pressure for Flowing Well.....

Pumping Water Level 61 feet
at 5 gal. per minute.

Discharge in gal. per min. of flowing well .....

How Tested Pump

Length of Test 24 Hours

Remarks: (Gravel packing, cementing, packers, type of shutoff).....

.....

.....

.....

.....(Continue on reverse side)

¼ Sec. 13 T. 31 R. 34
Indicate location of well and place of use, if possible. Each small square represents 40 acres.

USE—If used for irrigation, industrial, drainage or other. Explain, state number of acres and location or other data (i.e.: Lot, Block and Addition).

.....

.....

.....

Show exact depth of bottom.

152

(29)

ADMINISTRATOR OF [illegible]
OFFICE OF STATE ENGINEER

Notice of Completion of Groundwater Appropriation by Means of Well

DEVELOPED AFTER JANUARY 1, 1962

(Under Chapter 237, Montana Session Laws, 1961)

Top of Ground

(Elev. above sea level 2000')

Clay

3' large rocks

4" galvanised pipe

4' smaller rocks

15' Perforated pipe

¼" holes

hard pan with water

water

Show exact depth of bottom.

Owner...Clifford D. Dare...Address Rte. #3, Troy, Mont.

Driller...Clifford D. Dare...Address Rte. #3, Troy, Mont.

Date of Notice of appropriation of groundwater.....

Date well started March 15, 1962 ate completed March 24, 1962

Type of well...Driven...Equipment used...Rotary Air Hammer...
(Dug, Driven, bored or drilled) (Churn drill, rotary or other)

Water use: Domestic ☒ Municipal ☐ Stock ☒ Irrigation ☒
Industrial ☐ Drainage ☐ Other ☐

Indicate on the diagram the character and thickness of the different strata met with in drilling, such as soil, clay, shale, gravel, rock or sand, etc. Show depth at which water is encountered, thickness and character of water-bearing strata and height to which the water rises in the well.

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS		
				Kind Size	From (Feet)	To (Feet)
4"	4" Galvanised			¼"	14	19

Doc. No. 755
Filed for record this 28 day of April A. D. 19 62, at 10:45 o'clock A M.

N / W / E / S

Sec 12 T 31 R 34

Indicate location of well and place of use, if possible. Each small square represents 40 acres.

Static Water Level for non-flowing well ....19.... feet.

Shut-in Pressure for Flowing Well.....

Pumping Water Level....90.... feet at....1600.... gal. per minute.

Discharge in gal. per min. of flowing well .....

How Tested....Pump.....

Length of Test....3 days.....

Remarks: (Gravel packing, cementing, packers, type of shutoff).....
Not applicable

.....(Continue on reverse side)

USE—If used for irrigation, industrial, drainage or other. Explain, state number of acres and location or other data (i.e.: Lot, Block and Addition).

Domestic

Driller's License Number [illegible]

Clifford D. Dare
Driller's Signature

117701

This form to be prepared by driller, and three copies to be filed by the owner with the County Clerk and Recorder in the county in which the well is located, tissue copy to be retained by driller.

Please answer all questions. If not applicable, so state, otherwise the form will be returned.

Form 2 — Approved Stock Form — Ware Publishing Co. Helena, Montana 42329

(30)

File No. ..... RECEIVED 60

T 31 R 34

DUPLICATE

County Lincoln

LOG

STATE OF MONTANA
ADMINISTRATOR OF GROUNDWATER CODE
OFFICE OF STATE ENGINEER

Notice of Completion of Groundwater Appropriation by Means of Well

DEVELOPED AFTER JANUARY 1, 1961

(Under Chapter 237, Montana Session Laws, 1961)

Owner John & Viola Molymaux Address 9146 Yardmaw

Driller John Molymaux Address Coeur D'Alene Idaho

Date of Notice of appropriation of groundwater Nov. 18th 1971

Date well started 15th July 1963 Date completed 12th Sept. 1963

Type of well Dug & Driven Equipment used Truck with winch and 2" pump

(Dug, Driven, bored or drilled) (Churn drill, rotary or other)

Water use: Domestic ☒ Municipal ☐ Stock ☐ Irrigation ☒ yard & garden
Industrial ☐ Drainage ☐ Other ☐

Indicate on the diagram the character and thickness of the different strata met with in drilling, such as soil, clay, shale, gravel, rock or sand, etc. Show depth at which water is encountered, thickness and character of water-bearing strata and height to which the water rises in the well.

Size of Drilled Hole	Size and Weight of Casing	From (Feet)	To (Feet)	PERFORATIONS		
				Kind Size	From (Feet)	To (Feet)
4 inches	4 inches	1 ft Bot	22 ft	1/8 in	17 ft	22 ft

Top of Ground

(Elev. above sea level 1889 ft)

Bot Cement for pump 6' x 6' by 7 feet deep.

7 ft

Gravel all the way

Water Level

22 ft Driven

Bottom

Show exact depth of bottom.

Doc. No. 117

Filed for record this 24 day of Nov A. D. 19 71, at 11:22 o'clock A M.

N / W / E / S

Static Water Level for non-flowing well 1.1 feet.

Shut-in Pressure for Flowing Well (no) .....

Pumping Water Level 1 feet at 10 gal. per minute.

Discharge in gal. per min. of flowing well (no) .....

How Tested ½ H.P. 6" pr gallon pump

Length of Test 2 hrs

Remarks: (Gravel packing, cementing, packers, type of shutoff) .....

Steel & Pipe well pump

(Continue on reverse side)

¼ ..... Sec. 13 T. 31 R. 34

Indicate location of well and place of use, if possible. Each small square represents 40 acres.

USE—If used for irrigation, industrial, drainage or other. Explain, state number of acres and location or other data (i.e. Lot, Block and Addition).

Place of use — Tract 13 see Haystaka

Pleasant Survey 31 32 — see Tab 14

see key sheet

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Driller's License Number (none)

WELL LOG REPORT

From	To	Material
0	20	
20	30	Gravel with some
30	45	Clay
45		Gravel and Water

(use separate sheet if necessary)

9. DATE STARTED August 20, 1977
DATE COMPLETED August 31, 1977

10. WAS WELL PLUGGED OR ABANDONED? ___ Yes ___
If so, how?

11. DRILLER'S CERTIFICATION
This well was drilled under my supervision and this report is true to the best of my knowledge.

B. & B. Drilling Co. 151
Driller's or firm name License No.

P. O. Box 967, Lewis, Montana 59457
Address

Ronald A. Bo[illegible]
By